POWER

A McGRAW-HILL PUBLICATION—ESTABLISHED 1884
ELY C. HUTCHINSON, *Editor*

Volume 71 NEW YORK, JUNE 3, 1930 *Number* 22

They Went Through

WHILE others were making a big noise getting ready and keeping the front pages of the dailies hot with what they were going to do Lindbergh slipped off quietly and landed at Paris.

Byrd took an expedition into the Antarctic, lived there all summer, visited the pole, brought everybody out alive and well with more information than any previous explorer had been able to acquire.

These achievements are being constantly paralleled by the accomplishments of engineers. In fact, they are themselves essentially of the engineering type.

Men of initiative and vision see the possibilities of higher pressures, higher temperatures, greater capacities in power-plant practice.

They are reaching out into unexplored territory. The testing out of their ideals involves the putting to the hazard of enormous sums of money, the stability of services operating in known and proved domains, the risk of prestige and reputation.

But materials are found, designs are developed, the available best is brought together to effect the untried attainable. The great adventure succeeds and another stride is made into the unknown.

Capability through long and intimate association with the subject. Knowledge and use of all that would contribute to success. Organization of the best brains, skill, design, material, craftsmanship, and manipulation.

The "know-how" and infinite pains in its application. These backed by courage, conviction, and confidence spell progress and success.

F. R. Low

EDITORIALS

Receptivity

WHILE not denying credit to the great inventors whose names attach to the mileposts on our road to progress, it has been said that inventions are but the product of the economic necessity of their time, and the inventors a sort of lighting-rod gentry through whom the high potential of public necessity was brought to ground.

Maybe so; but have not these men, by temperament, preparation, and training, so increased their conductivity that they offer no resistance to the new? Their receptivity is high.

Whether he be inventor, power plant owner, or operator, it is receptivity that counts. New thoughts, new ideas, modern devices, new ways for doing old jobs better and more cheaply, should be allowed to strike in, and their possibilities as profit builders run to ground. It pays.

Boiler Operation Is Becoming Safer

THERE has recently come to hand a bound volume of "The Locomotive," issued quarterly by the Hartford Steam Boiler Inspection & Insurance Company, in which is printed a list of nearly two thousand boiler accidents occurring during 1927 and 1928. What proportion this is of the total number of such accidents is not known. The casualties were 222 killed and 461 injured.

While a comparison of two succeeding years is hardly indicative of any trend, it is a fact that there were more higher pressure plants in service in 1928 than 1927. Viewed from this angle, some of the figures presented are interesting. Although the number of failures in 1928 was greater by over two hundred, they were, in general, less serious, and accounted for only half as many killed and fewer injured. The number of tube failures was greater by fifty per cent in the latter year. The casualties resulting from this cause were proportionately small, but sufficient to emphasize the necessity of taking every precaution against injury from such cause.

Fifteen years ago *Power* maintained a record and compiled a list of boiler accidents over a period of two years. The number of casualties per accident was three times as great as shown by the "Locomotive" list. Thus it would appear that in spite of the more critical service to which boilers are being put they are showing a better record for safety, due no doubt to better construction and more intelligent operation.

Better Hydraulic Laboratory Research Facilities

PRESIDENT HOOVER recently signed the bill that authorizes the construction of a national hydraulic laboratory at the Bureau of Standards, Washington, D. C. This bill as passed, after eight years of effort by the engineering profession, provides funds to construct and equip a laboratory for determination of fundamental data useful in hydraulic research relating to the behavior and control of river and harbor waters, the study of hydraulic structures and water flow, and development and testing of hydraulic instruments and accessories.

In providing this laboratory Congress has made an outstanding contribution to hydraulic engineering, but it is not expected to meet all our needs for hydraulic research. Several European countries support national hydraulic laboratories, but in the majority of cases the large laboratories of this kind are in the universities. These laboratories conduct a wide variety of experiments; whereas the governmental laboratories, as a rule, have been constructed for specific classes of work.

Heretofore, not only has this country been without a national hydraulic laboratory, but there has been a general lack of these facilities—and there still is. Even the addition of a national hydraulic laboratory will not remove the deficiency. More university and more industrial laboratories are required. Scarcely an important hydraulic structure is designed that cannot be improved by tests on models. Practically without exception, when such tests have been made, improved designs and a substantial reduction in construction cost have resulted.

The successful way that some of our universities have been conducting hydraulic research is evidence that, with the proper support, these facilities can be made equal to those in Europe. Some of our university laboratories are ideally located to conduct hydraulic research work of every kind, and should be encouraged to do so. This will not in any way interfere with the work of the national hydraulic laboratory. Other research laboratories, in universities and industrial establishments, have not conflicted with the present Bureau of Standards. All of these laboratories have made contributions of inestimable value to industrial progress. Each has its place in the search for new facts and the application of known principles, and they have continually extended their facilities. Similarly, the national hydraulic laboratory, instead of decreasing the demands on our present hydraulic testing facilities, will quicken the demand for an extension of them.

Jobs for Graduates

SPRING blossoms on the campus once served as a gentle reminder to seniors that the job-hunting season had arrived. But times have changed. Today most of the prospective graduates are "signed up" before winter has passed. It is significant that this applies to 1930 as well as it did to 1929—a general slackness in employment has not affected the graduating class. Personnel directors of our large industries at the eleventh annual industrial conference of the Pennsylvania State College reported that the demand for this year's seniors in engineering schools is many times the supply.

It was not always thus. In the early years of engineering education the young graduate was looked upon with skepticism. American industries had flourished under the leadership of men trained almost exclusively in the school of hard knocks. Lacking practical experience, and filled with theory that was considered of no value, the young graduate faced a cold reception and less than a living wage.

Years in industry were needed to live down a college degree and get a reputation for knowing something and being somebody in spite of an "education." It was largely to offset this unfavorable impression that shop work and so-called "practical" courses were stressed so much in the colleges of twenty-five years ago.

Two factors are prominent in the changed situation. First, many of the key positions in industry are now held by engineering graduates. Their attitude is naturally sympathetic toward education. This insures a square deal for the college man; yet it does not account for a demand that exceeds the supply. Second, such a demand proves conclusively that the graduate has something which industry can use. That something seems to be a thorough grounding in scientific fundamentals, plus ambition and an open-minded approach to new problems.

Laying Up the Heating System

WITH June here it is generally considered safe to lay up the heating system for the summer, and to commence those maintenance jobs that could not be done during the heating season because equipment was in continuous use. It is now that a record of trouble experienced while heat was on becomes the engineer's friend, reminding him of the many little things to be done in the summer.

The care with which boilers, pumps, regulating valves, etc., are laid up for the idle months will be reflected in the ease with which the heating system is started in the fall and in the lack of trouble during the next heating season. Do not procrastinate! Start now the job of draining, cleaning, and filling boilers, renewing valve and pump packing, grinding or replacing valve seats, draining and cleaning condensate receivers, and the many other jobs too numerous to list here.

▼

POWER *Stands for . .*

1. Making Power When It Should Be Made
2. Buying Power When It Should Be Bought
3. Cheaper Power Through Modern Equipment
4. Easier Financing of Equipment Purchases
5. Better Use of Byproduct Heat and Power
6. Operating Methods That Save Money
7. Less Waste in Transmission and Application
8. Prevention of Smoke, Within Reason

▼

OTIS BUILDING BLOCK PLANT

A PROFITABLE VENTURE

Light, heat, and power free for the building, and a sizable profit besides, summarizes the record of a remarkably successful block plant in Chicago. Including building services at equitable rates, the annual surplus over operating expenses now exceeds $60,000 per year on an initial investment of $100,000

C. H. Langs, superintendent of Otis Building

IN 1911 and 1912 when the sixteen-story Otis Building in Chicago was under erection the question of installing a power plant or purchasing the electrical and steam services was finally settled in favor of the former, largely through the business acumen of the present superintendent, C. H. Langs, who was then in the employ of the owners. With block service in mind, he laid out a plant of greater capacity than actually was required by the building, of 3,443,000 cu.ft. content. The generating capacity of 850 kw. was excessive, but as the block plan developed all of it was needed, and, incidentally, notwithstanding the investment, reports show that the plant paid for itself in four years by savings over the costs that would have resulted from purchased services, although ten years was taken to retire the investment.

Four direct-current generating units were installed: two of 300-kw., one of 150-kw., and one of 100-kw. capacity, all driven at comparatively low speed by non-releasing four-valve corliss engines. Three 3,000-sq.ft. horizontal water-tube boilers operating at 150 lb. pressure met the requirements at first, but space was left for a fourth boiler, which was installed in 1924 and equipped with five oil burners, so that it could be brought up quickly as a relief unit. The other boilers are served by natural-draft chain-grate stokers.

It may be of interest to state that this plant, without emergency connections with the utility system, has never had a serious interruption in any of its services.

Operation started in May of 1912. In the summer of 1913 the first outside building was taken over to heat. In succeeding years more customers were added, until at the present time the Otis Building plant does the entire heating of the block and supplies 60 per cent of the current for light and power. In other words, heat and hot water is furnished to 11,680,700 cu.ft. of building space, including that of the Otis Building. In the block there are five restaurants that require high-pressure steam for cooking. The returns in all cases are brought back to the plant. All buildings taking current are equipped with electric elevators.

A summary of results over a ten-year period is given in the table on page 860. Beginning with the year ending May 1, 1920, and continuing to May 1, 1929, it will be seen that the annual coal consumption has varied, depending upon the severity and duration of the heating season, but the average has been close to 11,000 tons, which reduces approximately to 1 ton of coal per year per 1,000 cu.ft. of space. Over fifteen years the price per ton has averaged close to $5.60. For the ten-year period under consideration in the table the space heated aggregated 10,825,700 cu.ft. A recent addition of 855,000 cu.ft. increased the total to the figure previously given.

Since the installation of the oil-fired boiler in 1924, whenever fuel oil has been low priced it has been used in addition to the coal, as, for example, in 1925 and 1929. It was used also last season, plant records showing for the first nine months of the fiscal year a consumption of 8,375 tons of coal and 235,687 gal. of oil. The total price of fuel appears in a separate column.

Besides supplying heat and hot water wherever needed by the use of exhaust steam, the tabulated quantities of

fuel have produced electrical energy in the amounts given. The growth in load has been gradual, reaching in the year 1928-29, 2,250,000 kw.-hr., and, judging from the figures for the first nine months of the present year, the annual total will approximate 2,375,000 kw.-hr. The Otis Building alone requires about 800,000 kw.-hr., or, roughly, one-third of the present total.

To handle this load it has been customary to operate two boilers at the most efficient point, 150 to 175 per cent of rating, and when the demand goes past their economical capacity a third boiler, preferably the oil burner, is placed on the line. Electrical loads average well up to 600 kw., with peaks in excess of this amount, so that it is necessary at times to operate three of the generating units.

In the power plant the operating crew consists of three firemen, one boiler washer and one handyman in the boiler room, and six operating engineers and one oiler in the engine room. Besides their regular duties the engineers do all the mechanical and electrical maintenance work in the Otis Building and some work in the other buildings served. A gradual increase in the payroll column will be noticed. This means not more men, but higher wages, for the number in the force has remained constant, and most of the original employees are still engaged. Maintenance of mechanical equipment naturally varies. In certain years the amount expended for repairs may be trifling and in others heavy, as indicated in the table, so that data of this character should be averaged over a period of years. Such an average is available for a period of fifteen years, showing the annual expenditures for miscellaneous power plant supplies, such as oil, waste, packing, boiler compound, stoker parts, boiler tubes, and other items, approximate $2,718. Average cost for boiler repairs has been $666 a year; for repairs to stokers and suspended arches, $240; engine repairs, $66; and generator repairs, $80 a year. The annual average for supplies and repairs totals $3,770, compared to $4,170, the average for the ten years listed in the table.

Steel encased cooling tower on roof of Otis Building

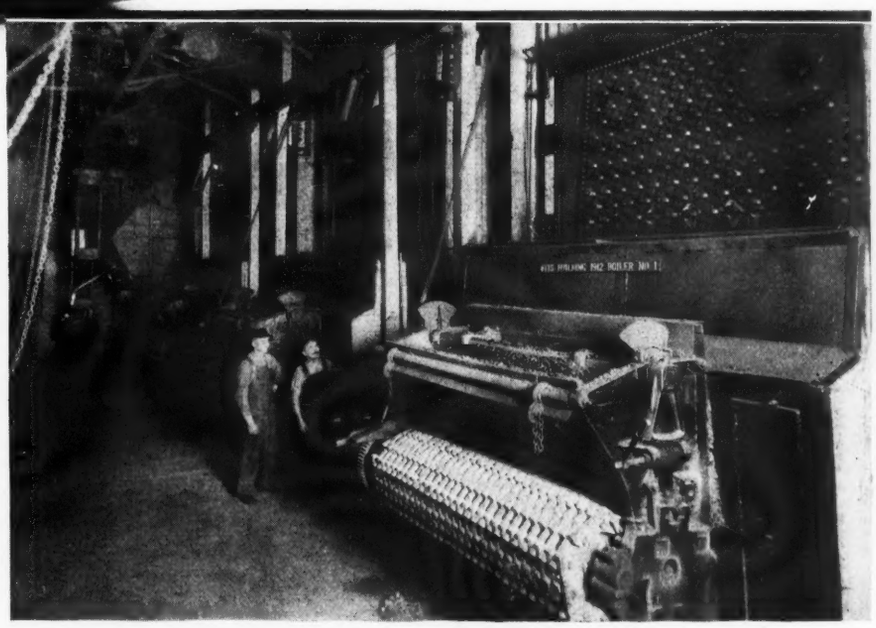
Revenues from the sale of steam and electrical energy are increased by charges for miscellaneous services performed for customers and for certain maintenance work in the Otis Building. The totals include all expenses and all revenues, and their differences show the operating profits from year to year.

To interpret the profit column it must be understood that proper charges should be added for Otis Building services, as they do not appear in the figures of the table. The revenues are from outside steam and electrical customers and from retailing of current to the tenants of the Otis Building. Free services for this building include heating, power for the elevators and ventilating equipment, public lighting in corridors, etc., and general building maintenance work done by the power plant crew.

Taking the year ending May 1, 1927, as typical, these services at reasonable rates amount to $49,800. This sum added to the $12,484 listed gives a profit to the power plant that exceeds $62,000 per year, and in succeeding years the profits are greater. The minus signs higher up in the profit column simply mean that the building was getting annually $50,000 worth of service for the amounts listed. If this sum were added annually, the profits would range from $17,000 to $65,000. No overhead has been included, because the total investment was written off during the first ten years in the life of the plant.

The foregoing also applies to taxes on the plant. For taxing purposes the value of the plant always has been added to that of the building and the tax determined on the total, so that this item did not enter into the accounts of the engineer. For different parts of the building and the equipment, different percentages of write-off in the value have been allowed. In the power plant the annual reduction has been 10 per cent of the original value, so that after the first ten years there was no plant value to tax. New additions, such as the low-pressure turbine, are added to the value of the building, and the same rate of write-off allowed each year. Owing to the tax situation in Chicago, this item has not as yet been determined. Another item, that of boiler insurance, amounting to $70 per year, does not appear. But the sum total of both items would not materially alter the balances given in the table.

As the heating and electrical loads developed, a good

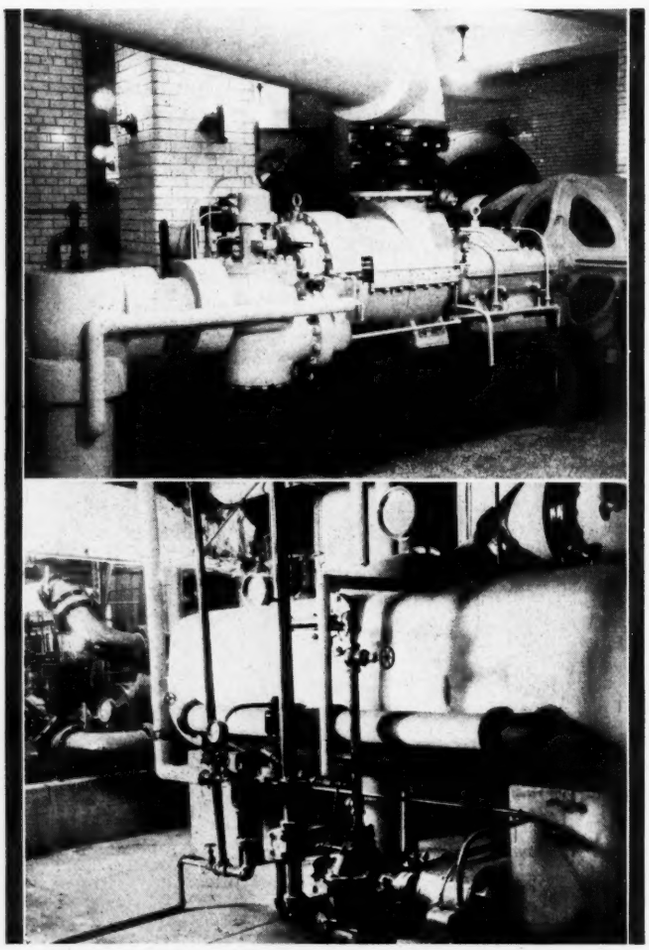


Boiler room of Otis Building, containing three stoker-fired and one oil-fired boiler

TEN YEARS' OPERATING AND COST DATA

Year Ending May 1	Coal, Tons	Fuel Oil, Gal.	Total Fuel Bill	Kilowatt-Hours	Payroll	Supplies and Repairs	Ash Removal and Misc. Items	Total Operating Expense	Steam Revenue	Electrical Revenue	Revenue From Service to Customers and From Bldg. Maintenance	Total Revenue	Operating Profit
1920	10,550	.....	$62,967.40	1,116,730	$19,796.48	$2,990.00	$2,748.16	$88,502.04	$15,984.48	$39,958.36	$1.03	$55,943.87	—$32,558.17
1921	9,366	.....	64,346.76	1,163,660	25,536.81	892.11	7,751.88	98,527.56	23,166.42	43,257.51	824.07	67,248.00	— 31,279.56
1922	10,685	.....	72,197.81	1,435,330	27,108.82	6,385.92	3,905.90	109,598.45	29,090.64	52,483.82	852.18	82,426.64	— 27,171.81
1923	11,797	.....	77,299.04	1,525,300	26,262.24	2,981.39	4,228.90	110,771.57	31,373.07	56,325.80	762.51	88,461.38	— 22,310.19
1924	11,856	.....	63,901.49	1,584,900	27,841.39	3,437.57	4,412.08	99,592.53	31,740.36	60,040.27	988.44	92,769.07	— 6,823.46
1925	11,181	140,259	63,153.30	1,625,400	31,776.59	3,498.03	5,776.11	104,104.03	27,295.80	65,627.40	788.11	93,711.31	— 10,392.72
1926	11,721	.....	63,820.93	1,746,024	29,517.61	5,570.05	4,416.53	103,325.12	26,485.71	73,181.40	4,188.41	103,855.52	530.40
1927	10,643	.....	58,104.31	1,716,200	30,949.92	4,765.70	4,383.10	98,203.03	30,343.38	74,865.78	5,478.78	110,687.94	12,484.91
1928	12,039	.....	67,729.87	2,122,000	31,537.72	4,292.32	4,228.39	107,788.30	35,299.61	84,396.13	4,159.60	123,855.34	16,067.04
1929	12,037	87,879	68,371.78	2,250,000	35,833.05	6,892.67	3,728.76	114,826.26	38,252.50	85,670.47	4,790.56	128,713.53	13,887.27

steam balance was established. Practically all of the exhaust steam was being utilized during the colder months of the year. In the summer, however, about 10,000 lb. per hour of exhaust steam was being wasted to atmosphere during periods of heavy load, and in the moderate weather of spring and fall a lesser amount was wasted. An estimate gives the total steam dissipated during six months of the year as 18,000,000 lb. That did not conform with Mr. Langs' conception of the ultimate economy to be obtained, so he conceived the unusual plan, for an office building, of installing a low-pressure turbine-generator of 200-kw. capacity to not only eliminate this unnecessary waste, but also to provide the additional reserve capacity that had been needed for some time. With peaks exceeding 600 kw. it had been necessary to operate three of the generating units. It will be seen that the turbine would be needed to help carry the maximum load if one of the large machines were down.



Low-pressure turbine-generator (above) of 200-kw. capacity, and surface condenser (below)

According to the guarantee, the new machine requires 40 lb. of steam at 3 lb. pressure to deliver a kilowatt-hour, so that at rating it will use 8,000 lb. of steam per hour. The exhaust from engines and pumps that are running is collected in a large receiving tank in the boiler room. The tank is vented to atmosphere through a back-pressure valve. An 8-in. pipe conducts the steam to the turbine. A location in the boiler room about 30 ft. distant from the turbine was the only space available for the condenser, which is of the horizontal type with 1,100 sq.ft. of surface. The turbine steam rate and cooling water at high temperature made it desirable to install 5½ sq.ft. of condenser surface per kilowatt.

Economy dictated conservation of the condenser supply by the installation of a cooling tower. This equipment naturally was placed on the roof of the building. Fire regulations prohibited an open tower with wooden louvers and natural ventilation, so a steel-inclosed tower, 12x19 ft. in plan and 34 ft. high, was installed, with an 84-in. airplane propeller fan at each end driven by a 9-hp. motor. The tower is guaranteed to cool 850 gal. of water per minute from 105 to 85 deg. F. Water flows by gravity from the tower pan to the condenser, and is returned by a motor-driven circulating pump operating against a head of 240 feet.

The low-pressure turbine unit went into operation on Sept. 9 last, and ran daily up through Nov. 21 for a total of 608 hr. During this period the machine generated 108,438 kw.-hr. An estimate places the auxiliary power consumption at 22,496 kw.-hr., leaving a net output of 85,942 kw.-hr. Utility rates are obtained for the current. At an average price of 5c. per kilowatt-hour the net salvage from waste steam amounted to $4,297.10.

It is planned to utilize the low-pressure turbine to the fullest extent. It will be operated at full load throughout the summer, and in the late fall and early spring at part load whenever there is a sufficient surplus of exhaust steam. The expectation is to net at least 300,000 kw.-hr. per year. At a 5c. rate the return would be $15,000 on an investment of $35,000. Allowing 16 per cent to cover depreciation, interest, and other items that are common to an investment of this character, the net profit reduces to $9,400. If the possibilities have been properly analyzed, and it would seem that the estimates are conservative, the total investment will be written off in four years and there will then be an increment of $15,000 to be added to the net profits of the plant.

Torsional Vibrations and Critical Speeds in Diesel-Generators

A practical outline of how to figure critical speeds produced by torsional vibration of crankshafts of Diesel engines direct connected to alternating-current generators. How the design of a Diesel, particularly of its flywheel, is influenced by requirements of parallel operation

B. V. L. MALEEV
Consulting Engineer, Hollywood, Calif.

TORSIONAL VIBRATION, or oscillation, of a shaft is a phenomenon of repeated twisting of a shaft first in one direction, then in the opposite, then again in the first direction, each section of the shaft oscillating about some mean position. Even comparatively small forces acting in planes perpendicular to the center line of a crankshaft can produce great angular motion of crankshaft sections if they occur at regular intervals and if their number of applications is equal to or is in a simple ratio to the number of natural frequencies of the shaft. Great angular motion of sections and resulting high stresses applied for any length of time have a tendency to produce crystallization, fatigue of material, and, finally, failure of the shaft.

The engine speeds at which pronounced vibration and great angular deflections occur are called critical speeds. Many shaft failures in the past can be explained now by torsional vibration and critical speeds, and, in turn, careful investigations of an existing engine permit of the detection of dangerous torsional vibrations at certain speeds, and also can show how to reduce these vibrations to harmless proportions.

Furthermore, recent investigations have shown that excessive vibration at critical speeds can produce crystallization and failure not only in crankshafts, but also in crankpin-bearing-, main-bearing-, and cylinder- hold-down bolts.

I know of several cases of breakage of crankpin-bearing bolts, some of them accompanied by bending of the connecting rod and wrecking of the crankcase, piston, and even cylinder. In one make of a vertical engine these breakages occurred mostly on six-cylinder types, seldom on four-cylinder, and never on single- or two-cylinder units. As all the engines had crankshafts of the same diameter, the critical speed of the six-cylinder engine was considerably lower than of the other engines, due to the greater shaft length, and therefore the torsional vibrations were more pronounced.

For the engine designer it is most important to be able to determine the critical speeds in advance and to so design the engine as to avoid the occurrence of dangerous torsional vibration; in other words, get away from critical speeds. The problem has attracted the attention of many engineers, and at present can be considered fairly well solved from the theoretical standpoint. However, the average designer is not eager to go into complicated and wearisome mathematical computations and graphical developments, but will sacrifice, to a certain degree, the accuracy of the results if fairly close approximations can be obtained by the use of a few simple formulas.

Two possible causes of the setting up of dangerous torsional vibrations exist in oil engines direct connected to alternating-current generators—the first cause is a synchronism between the firing impulses of the engine and the natural frequency of the engine shaft, taking in consideration the flywheel effects of all rotating parts of the engine-generator unit. The second cause is a synchronism between the firing impulses of the engine and the natural oscillating frequency of the unit as determined by the electrical forces of the alternator.

Regardless of the cause, the natural frequency of the

TABLE I—ENGINE DIMENSIONS

Stroke, in.	20
Revolutions per min.	240
Diameter of crankshaft, in.	9
Diameter of extension shaft, in.	7
Weight of revolving parts on each crank, lb.	650
Weight of reciprocating parts on each crank, lb.	700
Weight of flywheel, lb.	6,100
Weight of generator rotor, lb.	2,425
Radius of gyration of cranks, in.	10
Radius of gyration of flywheel, in.	34
Radius of gyration of rotor, in.	25.6

system must differ considerably, at least by 0.20 per cent, from the forced impulses received by the crankshaft, whether of mechanical or electrical nature. Also, in both cases the type of cycle of the oil engine, whether two-stroke- or four-stroke, will determine the critical speed that must be avoided.

The natural frequency of a shaft with several rotating members attached to it can be computed from the formula

$$f = \frac{1}{2\pi}\sqrt{\frac{IGg}{\Sigma(l \times WR^2)}} \qquad (1)$$

where

f = Frequency in complete oscillations per second.
I = Polar moment of inertia of a shaft section in in.^{4}.
l = Distance of a rotating member from the node, in.
W = Weight of a rotating member, lb.
R = Radius of gyration of a rotating member, in.
G = Modulus of elasticity of the shaft material; about 12,000,000 lb. per sq.in. for open-hearth steel.
g = Acceleration due to gravity = 386 in. per sec. per sec.

If we substitute for f its value in terms of F, the frequency in complete oscillations per minute, or $F = 60f$, and also the numerical values for π, G and g, we obtain

$$F = 645{,}000\sqrt{\frac{I}{\Sigma(l \times WR^2)}} \qquad (2)$$

The polar moment of inertia I of a round shaft is expressed in terms of the diameter d and may be written

$$I = 0.098d^4 \qquad (3)$$

If the shaft is not of the same diameter d on its entire length, but consists of sections of diameters d_1, d_2, d_3, etc., of length l_1, l_2, l_3, etc., then the equivalent lengths l' of a standard diameter d shaft are:

$$l_1' = l_1\left(\frac{d}{d_1}\right)^4 ; l_2' = l_2\left(\frac{d}{d_2}\right)^4 ; l_3' = l_3\left(\frac{d}{d_3}\right)^4. \qquad (4)$$

When a shaft is vibrating, whether in a linear or angular sense, at least one section is always at relative rest. This section is called a node, and the amount of angular deflection is measured in reference to this node. The exact location of a node in a crankshaft requires complicated computations. It is simpler to determine the location of the node from consideration of a dynamic equilibrium, that is, the position of the node can be found by considering the flywheel effects of all rotating members as though they were weights and locating the node at their center of gravity. And with sufficient accuracy for practical purposes a crankshaft can be treated as a straight shaft of the diameter of the journals.

When it comes to figure out the flywheel effect of the reciprocating parts, including piston, wrist pin and upper third part of the connecting rod, sufficient accuracy can be obtained if one-half of this weight is added to the weight of the crank and crankpin bearing.

To show the application of the formulas, let us find the critical speed of a four-cylinder four-stroke-cycle 300-hp. oil engine direct connected to a 225-kva. alternating-current generator.

Table I and the crankshaft drawing, Fig. 1, give the necessary data for the engine in question.

The equivalent length of the 12-in. long 7-in. diameter part between the flywheel and generator rotor, according to formula 4 is

$$12\left(\frac{9}{7}\right)^4 = 32.75 \text{ in.}$$

The flywheel effects of the cranks

$$= \left(650 + \frac{700}{2}\right) \times 10^2 = 100{,}000 \text{ lb.-in.}^2;$$

of the flywheel

$$= 6{,}100 \times 34^2 = 7{,}051{,}600 \text{ lb.-in.}^2; \text{ and}$$

of the generator rotor

$$= 2{,}425 \times 25.6^2 = 1{,}584{,}000 \text{ lb.-in.}^2$$

The flywheel effects, expressed in thousands of lb.-in.^{2}, and the equivalent lengths of a uniform 9-in. shaft are shown on Fig. 2.

A glance at Fig. 2 shows that the node of oscillatory vibration of the shaft will lie between the two main rotating members, the flywheel and the generator rotor, nearer to the flywheel, at a distance C from the center of the generator rotor. This distance C can be computed from the equation, using the dimensions shown in Fig. 2 and Table I, as

$$1{,}584C = 7{,}052(40.75 - C) + 100(28.87 + 40.75 - C) + 100(24 + 28.87 + 40.75 - C) \ldots\ldots$$

or

$$C = \frac{7{,}052 \times 40.75 + 100 \times 422.5}{1.584 + 7{,}052 + 400} = 36.5 \text{ in.}$$

This calculation shows that the node, or danger point, comes $40\frac{3}{4} - 36\frac{1}{2} = 4\frac{1}{4}$ in. from the center of the flywheel, or inside its hub, which is 12 in. long. In other words, the node is located favorably.

The natural frequency F from Formula 2, where

$I = 0.89 \times 9^4 = 643$ in.^{4}
$l = C = 36.5$ in.
$WR^2 = 1{,}584{,}000$ lb. = in.^{2}, works out as

$$F = 645{,}000\sqrt{\frac{643}{36.5 \times 1{,}584{,}000}} = \frac{645{,}000}{299} = 2{,}160 \text{ oscillations per minute.}$$

A four-cylinder four-stroke-cycle engine has two firing events per revolution; therefore, the main critical speed N_{ct} will be:

$$N_{ct} = \frac{2{,}160}{2} = 1{,}080.$$

Critical speeds of higher orders, second, third, and so on, may be considered, but they are usually not dangerous, giving only slight impulses; in this case they lie around 540 and 360 revolutions per minute.

We see that all critical speeds, including the third order, lie considerably above the engine speed of 240 r.p.m., and therefore the crankshaft can be considered perfectly safe. If the engine operated on the two-stroke cycle it would have four firings per revolution, and hence the critical speeds would have values one-half those in the four-stroke-cycle engine, or they would be 540, 270 and 180 r.p.m., and the crankshaft could still be considered safe. However, the critical speed of second order would be only 15 per cent above the engine speed, which is not as good as in the case of the four-stroke-cycle engine, where the critical speed even of the third order differs more than 50 per cent from the engine speed.

This relation between critical speeds of four- and two-stroke-cycle engines is partly responsible for the fact that more crankshaft failures have occurred in two-stroke-cycle engines than in four-stroke-cycle units.

On the other hand, we can readily see that the number of cylinders influences considerably the critical speed;

the greater the number of cylinders the lower the critical speed becomes.

To insure satisfactory operation of alternating-current generators driven by Diesel engines, according to the experience of builders of electrical generators, summed up in a formula given by Everest, the degree of irregularity S must be not more than

$$S = \frac{M}{6P} \qquad (5)$$

where

M = Number of impulses per revolution.
P = Number of poles of the alternator.
S = degree of irregularity.

On the other hand, the degree of irregularity of rotation of an oil engine can be figured from a formula, originally given by H. Guldner, which, expressed in English units and referred to b.hp. instead of i.hp. and with the assumption that the average mechanical efficiency $O_m = 0.80$, can be presented as

$$S = \frac{302 \times 10^6 \times K \times hp.}{WR^2 \times n^3} \qquad (6)$$

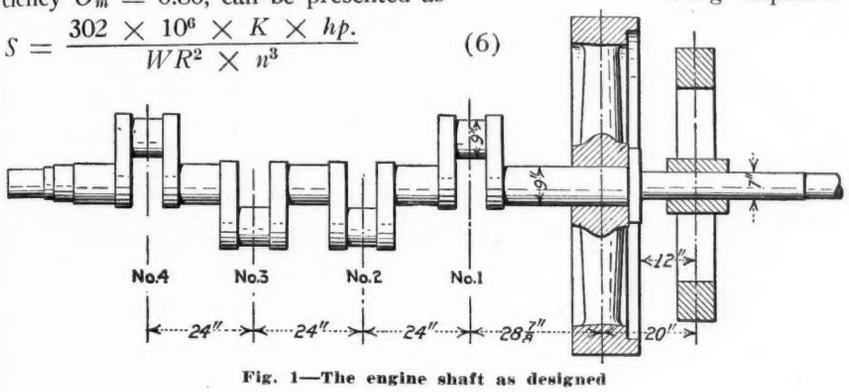


Fig. 1—The engine shaft as designed

where K is a coefficient which depends on the type of cycle and number of cylinders and is given for single-acting engines in Table II, $hp.$ is the rated brake horsepower of the engine, WR^2 is the combined flywheel momentum in pound-feet^2 of the flywheel rim and the generator rotor, and n is the engine speed in revolutions per minute. In case of a four-cylinder, four-stroke-cycle engine the number of impulses per revolution $M = 2$; the number of poles of the generator is $p = 30$; thus the permissible degree of irregularity figures out by Everest's formula

$$S = \frac{2}{6 \times 30} = \frac{1}{90}$$

The actual irregularity of this engine unit can be computed from Guldner's formula, substituting for K the value 0.065 from Table II; and using 300 for the engine horsepower, and taking the flywheel effect value in pound-foot^2 from the figures given in the previous example, or

$$WR^2 = \frac{7{,}051{,}600 + 1{,}584{,}000}{12^2} = 60{,}000 \text{ lb.-ft.}^2$$

and using an engine speed of 240, we find that

$$S = \frac{302 \times 10^6 \times 0.065 \times 300}{60{,}000 \times 240^3} = 0.0071 = \frac{1}{149}$$

We see that the degree of irregularity of the engine alternator unit is considerably smaller than required by the Everest formula $S = \frac{M}{6P}$. As we shall see later, the flywheel is made heavy to obtain not only a sufficient uniformity of rotation, but also to make the unit safe from torsional vibrations during parallel operation.

TABLE II—VALUE OF K IN GULDNER'S FORMULA

Number of Cylinders	Four-Stroke-Cycle Firing Order, Deg.	k	Two-Stroke-Cycle Firing Order, Deg.	k
1	720	1.0	360	.42
2	360	.44	...	...
2	180 and 540	.58	180	.11
3	240	.20	120	.062
4	180	.065	90	.038
6	120	.043	60	.008
8	90	.026	45	.001

For satisfactory parallel operation of alternators driven by internal-combustion engines the natural frequency of oscillation of the unit must differ at least 20 per cent from the frequency of any forced impulse, which may be called critical frequencies.

For four-stroke-cycle engines critical frequencies, which must be avoided, are particularly one-half the revolutions of the engine, because any irregularity in firing impulses in a particular cylinder occurs every other revolution. Secondary frequencies, of lesser importance, can occur with every revolution in engines with an even number of cylinders, and frequencies of third order corresponding to the number of firings can also occur, but rarely are of any consequence, usually being far above the natural frequency of the engine unit.

For two-stroke-cycle engines critical frequencies that must be avoided are equal to the engine revolutions, for the same reason. Frequencies of second and third order are still less likely to influence engine performance, being too far above the natural frequency of the engine unit.

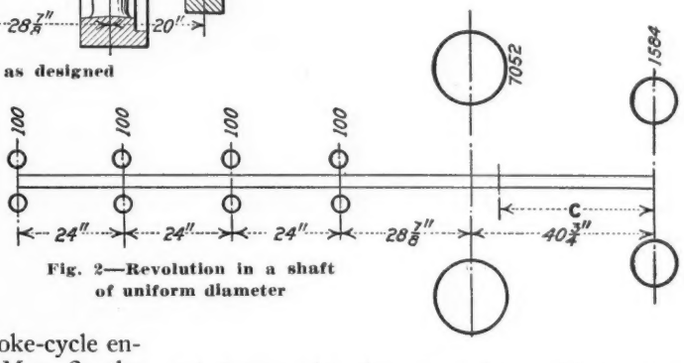


Fig. 2—Revolution in a shaft of uniform diameter

Table III contains these dangerous frequencies per minute for four-stroke- and two-stroke-cycle engines of different numbers of cylinders.

The natural frequency F in periods per minute of an engine-alternator unit can be figured from the following formula

$$F = \frac{35{,}200}{n}\sqrt{\frac{P_o f}{WR^2}} \qquad (7)$$

where

n = Revolutions per min.
f = Frequency of the alternator in cycles per second.
WR^2 = Combined flywheel momentum in lb.-ft.^{2} of the flywheel and rotor.
p_o = Kva. output when the rotor is continuously displaced from the no-load position by one electrical radian.

This synchronizing torque p_o can be computed for a

three-phase generator from the following formula:

$$P_o = \frac{C\sqrt{3} \times E}{1{,}000} \qquad (8)$$

where C is the sustained short circuit current at full voltage E. For a 2-phase generator

$$P_o = \frac{2CE}{1{,}000}$$

and for a single-phase unit $P_o = \frac{CE}{1{,}000}$ (9)

Obviously the natural frequency of a unit can be changed by changing the flywheel effect WR^2.

The normal procedure is to find the limits between which the natural frequency of the unit must not lie, to compute the corresponding WR^2 from Formula 7 and to compare them with the proposed WR^2 of the unit, and, finally to change the WR^2 of the unit to avoid any danger of critical speeds.

If the engines which must operate in parallel have different speeds, then each engine must avoid natural frequencies corresponding to its speed and also to the speed of the other engine.

If two engines as analyzed must operate in parallel with a normal speed $n = 240$ r.p.m., then, according to Table III, the natural frequency of four-cylinder, four-stroke-cycle engines must not lie particularly between $\frac{240}{2} \pm 20$ per cent, or between 96 and 144 r.p.m., and if we want to take in consideration frequencies of the second order, also not between 240 ± 20 per cent, or between 192 and 288.

The alternator being a 3-phase, 2,300-volt unit with a value of C — 105 amp., we find from Formula 8 the synchronizing torque

$$P_o = \frac{105 \times \sqrt{3} \times 2{,}300}{1{,}000} = 418 \text{ kva.}$$

The values WR^2 can be computed from Formula 7 as

$$WR^2 = \frac{(35{,}200)^2 P_o \times f}{F^2 n^2} \qquad (10)$$

As the number of cycles f of the alternator is 60 and substituting for F the values of 96, 144, 192 and 288, we find from the formula that the flywheel effect of the unit must not lie between 26,220 and 59,100 lb.-ft.² and, taking in consideration the secondary frequencies, also not between 6,550 and 14,780 lb.-ft.².

Therefore, the flywheel effect can be either between 14,780 and 26,220 lb.-ft.², or above 59,100 lb.-ft.². A check using Formulas 5 and 6 shows that the flywheel effect must be equal to or greater than 36,300 lb.-ft.² and therefore, considering the limits found from Formula 10, the flywheel effect must be made greater than 59,100.

This determined the size and weight of the flywheel as given in Table I, which was made almost twice as heavy as the standard design.

If the above analyzed engines must operate in parallel with an engine running at 277 r.p.m., then in addition to the danger zone of natural frequencies of 96 to 144 periods per minute a new danger zone of 111 to 166 periods per minute will be added.

However, the lower limit of dangerous frequency, 111 periods, is greater than 96 periods, to which the flywheel was fitted, and the flywheel effect being greater than required by Formula 10 no change will be required.

If the engines must operate in parallel with engines having a greater number of poles, and therefore running more slowly (for instance, 212 r.p.m.), the new danger zone will be 85 to 127 periods, and according to Formula 10 the necessary flywheel momentum will become 75,300 lb.-ft.².

After the two 300-hp. engine-alternator units were built with the dimensions as shown in Table I they were tested carefully in respect to torsional vibration.

The tests were conducted in the following manner: speed graphs were taken by a sensitive tachograph from both ends of the shaft, from the exciter end and from the end nearest to Cylinder 4. The speed graphs were taken at different speeds and loads: Over a range of 240 r.p.m. ± 20 per cent, starting with 192 r.p.m. and gradually increasing, by 5 r.p.m., to 288 r.p.m.; first with no load, next the same speed range with quarter load, then with half load, three-quarter load and full load.

The speed graphs thus obtained were all straight lines, did not show any speed fluctuation, and were identical for both ends of the shaft. This was a proof that there were no torsional vibrations at normal speed of the units equal 20 per cent.

These engines are operated always at the same speed, and therefore the margin of ± 20 per cent was ample. In the case of an engine running at different speeds (an industrial engine or a marine engine) the tests should be repeated for all speeds at which the engine might be operated with the same margins of ± 20 per cent.

TABLE III—DANGEROUS CRITICAL FREQUENCIES

Number of Cylinders	Four-Stroke-Cycle Engines: Main Freq.	Second Order Freq.	Third Order Freq.	Two-Stroke-Cycle Engines: Main Freq.	Second Order Freq.	Third Order Freq.
2	.5 n	n†	.....	n	2 n	...
3	.5 n	..	1.5 n	n	...	3 n
4	.5 n	n	2 n	n	2 n	4 n
5	.5 n	..	2.5 n	n	...	5 n
6	.5 n	n	3 n	n	2 n	6 n
8	.5 n	n	4 n	n	2 n	8 n

†n = engine r.p.m.

The method of checking the crankshaft and flywheel outlined in this article reduces itself to a few comparatively simple calculations. These calculations give means to insure both safe and satisfactory operation of the engines: safe in respect to preventing torsional vibrations, which can result in mechanical injuries to an engine, and satisfactory in respect to electrical requirements.

The same method of calculation can be used for engines connected to direct-current generators, centrifugal pumps, ship propellers, etc. The only difference is that in such cases the additional requirements for parallel operation are dismissed.

Carbon Deposits in Exhaust Ports

IN TWO-STROKE-CYCLE solid-injection Diesels there is a tendency for carbon and unburned fuel to deposit in the exhaust ports and pipes. The best way to remove it is to burn it out by torch. The inspection plates should be opened enough to admit sufficient air to consume the carbon.

Care must be taken to insure against firing the roof or adjoining property. The job should never be done when there is a wind.

What's What in
FLEXIBLE COUPLINGS—III

By F. A. ANNETT
Associate Editor of POWER

This is the last of three articles describing the different types of flexible couplings manufactured in the United States. Fifty-seven different designs are included. Although these do not embrace all the types manufactured, they are, in so far as the author has been able to ascertain, representative of the different classes of couplings

COUPLINGS in which the flexible member is a disk or ring, Fig. 35, are used extensively. Each hub is bolted to a flexible disk ring at three equidistant points. A central member between the hub is bolted to the disk rings at points midway between where the hubs are connected. This construction is used for large-sized couplings built in capacities up to 10,000 hp. and with a factor of safety of 5.

The flexible rings are made of laminated fatigue-resisting steel. Various arrangements of hubs and flexible rings are used, depending on the size of the couplings and the service to which they are to be applied. To take care of both parallel and angular misalignment, two flexible rings are required, connected to the coupling hubs in accordance with the principle indicated in the figure. In the smaller sizes this is done in such a way that the coupling's dimensions are comparable with those of the standard flange types. This design is known as the double-engagement coupling.

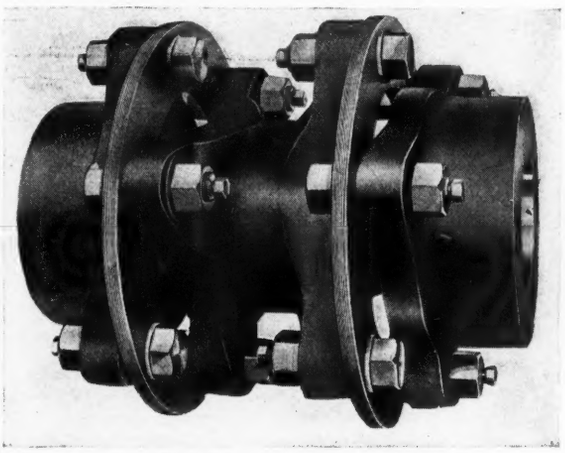


Fig. 35—The flexible members in this coupling are laminated-steel rings

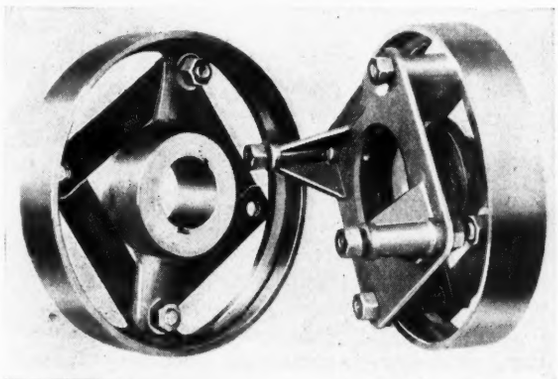


Fig. 36—Metal links form the equivalent of a square flexible disk

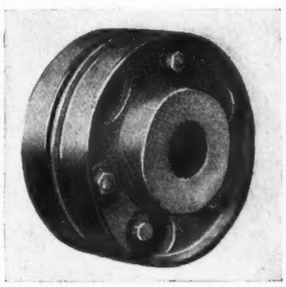


Fig. 37—The two halves of the coupling connect to a treated fabric disk

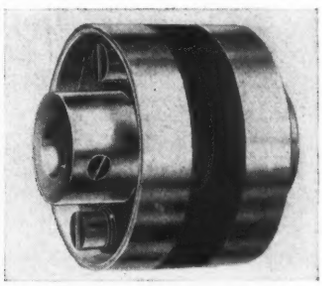


Fig. 38—Hubs connect at two points to a rubber disk

In the single-engagement type the two hubs are bolted to a single flexible disk. This coupling will take care of angular misalignment only. There are applications where such couplings are required. One of these is on a three-bearing drive: for instance, on a motor-generator set, where the motor has two bearings and the generator one. The shaft has angular misalignment only, but a coupling is required that will rigidly support the coupling end of the generator shaft. A single-engagement coupling with a metallic flexible ring answers the purpose.

Where there is considerable length of shaft between the power and the driven shafts, a single-engagement coupling may be used on each end of the intermediate shaft. These couplings rigidly support the intermediate shaft without bearings and take care of parallel and angular misalignment between the two machines.

In Fig. 36 the coupling's hubs are attached to the rims by two arms, to which are bolted four links. These links form the equivalent of a square flexible disk and are connected at two points to the corners of a square disk between the two halves of the coupling. This coupling is of the double-engagement type and is the equivalent of a two-disk coupling with an intermediate shaft between it. It can be operated in either direction and will take care of parallel and angular misalignment. In another type metal links are used to connect the two halves of the coupling, and the central disk is omitted.

Instead of a flexible metal disk, leather or treated heavy fabric disks are used. A coupling with treated-fabric disks is shown in Fig. 37. Each half of the

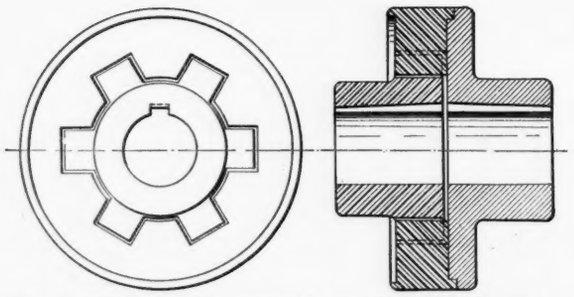
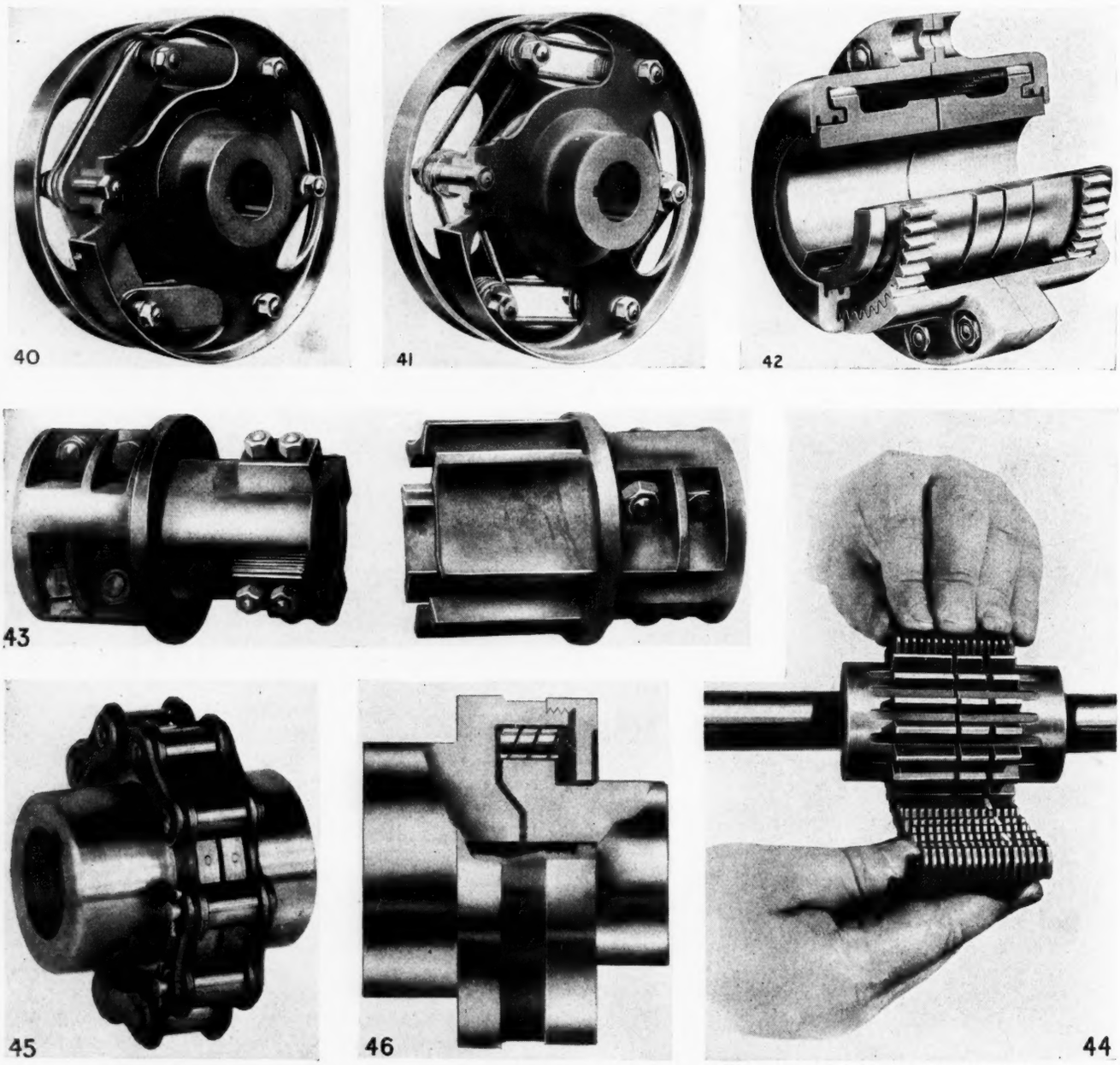


Fig. 39—This coupling operates on the principle of an external and internal gear

coupling is bolted to the disks at three equidistant points. The connections to the disks on one half of the coupling come midway between the connections to the other half. A coupling of this type will correct angular misalignment only. Where parallel mialignment must be compensated for, an intermediate shaft without bearings is employed between two couplings, and the combination can be used as a universal joint.

A light-duty coupling, Fig. 38, has a rubber disk for the flexible member. Four nuts, 90 deg. apart, are molded into the disk. Two of the nuts, 180 deg. apart, connect to one flange by screws, and the other two nuts connect to the other flange in the same way. The resiliency of the rubber disk is depended on for flexibility. The coupling is made in small sizes only.

Instead of using disks or disk rings, Fig. 35 and 37, links are employed, as in the coupling in Figs. 40 and 41. In Fig. 40 the links are leather, and in Fig. 41 they are made of steel-wire rope. In the latter the links are arranged with metal eyes mounted on eccentric bushings, by means of which the links can be adjusted to the proper tension. These couplings are made in medium and large sizes and will permit of a reasonable amount of



FIGS. 40 TO 46—LINK, GEAR AND CHAIN TYPE COUPLINGS ARE REPRESENTED IN THIS GROUP

Fig. 40—Leather links are the flexible member. Fig. 41—Same type as Fig. 40, except that steel-wire links are used. Fig. 42—Double-engagement spur-gear type coupling. Fig. 43—Flexible telescopic-type coupling to allow adjustment of the shaft endwise. Fig. 44—A piece of silent chain and two sprocket wheels constitute this design. Fig. 45—This coupling consists of two specially cut sprockets and a length of roller chain. Fig. 46—Spring rollers connect the internal with the external hub.

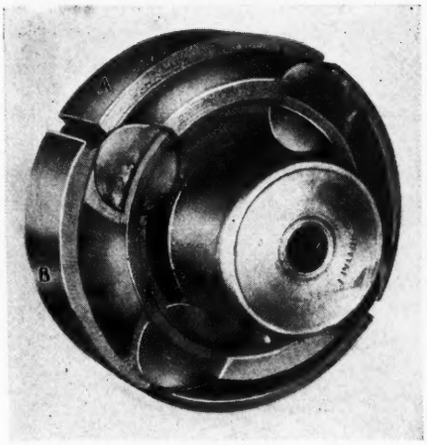


Fig. 47—Rubber rolls are the flexible members

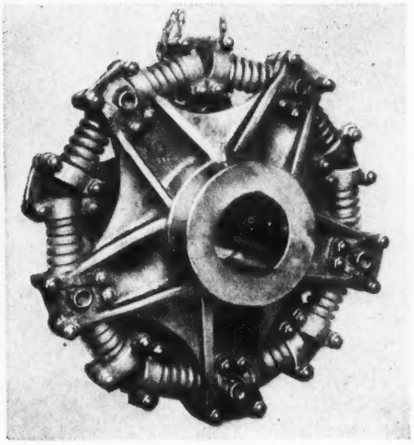


Fig. 48—Large capacity spiral-spring type coupling

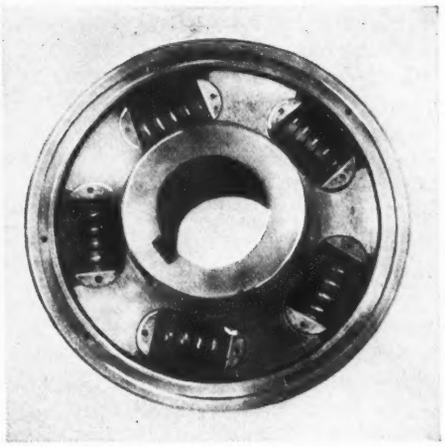


Fig. 49—Medium-capacity spiral-spring type coupling

angular misalignment and axial movement of the shafts.

The principle of an internal and external gear has been used extensively in flexible coupling design. That shown in Fig. 42 is of this type. On the outer periphery of each hub is a generated spur gear. Surrounding the hubs is a casing in each end of which is a generated internal spur gear. The internal gears engage the external gears on the hubs. In couplings of this type the flexible member is placed on ends of the hub opposite to where it is generally located. In this way the coupling is made to act as two flexible couplings with an intermediate section of shafting between them, and therefore it possesses a high degree of flexibility. After assembly the coupling is filled with oil. This type is built in sizes for one-inch shafts and up. When a large amount of end float is necessary one half of the casing is made longer than the other half to permit of having an internal gear with teeth long enough to allow for the end adjustment. The shaft section of this end of the coupling also has a long hub to permit of adjustment. These couplings are designed for up to 12 in. of lateral adjustment.

Fig. 43 is a telescopic-type flexible coupling designed for large end adjustment, such as required between a motor and a Jordan engine. It consists of a heavy split cylinder on which are bolted four columns of leather washers. The motor half of the coupling is a split cylinder, slotted to take the columns on the machine half. Construction is such that machines can readily be replaced without disturbing the coupling.

A coupling designed for slow speed is shown in Fig. 39. To the flange of one of the hubs is bolted a ring slotted on its internal periphery. The rim of one hub is slotted to mesh with the rim on the other.

One of the simplest types of flexible coupling consists of two sprockets with a section of silent chain connecting them, Fig. 44. A guide groove in one sprocket holds the chain in place, while the other is free to float under the chain. The chain fits loosely enough to take care of ordinary misalignment. Two specially cut sprockets and a length of roller chain comprise the coupling, Fig. 45. The clearance between the sprocket and chain side plates allows the coupling to adjust itself to all positions within its range. For couplings of the types in Figs. 44 and 45 that regularly accommodates angular misalignment and operate in a dusty atmosphere the use of oil casings is recommended. For the smaller couplings a revolving casing is employed. Stationary oil casings are used on large couplings and are held central around the coupling by supports.

Circular recesses are cut in the inner periphery of an internal hub of the coupling, Fig. 46. Similar recesses are cut in the outer periphery of an external hub. One hub is prevented from rotating inside the other by hardened steel spring rollers in the recesses of the two. The rollers make a loose fit. Inner working parts of the coupling are imbedded in a mixture of ground cork, grease, and graphite.

On the type of coupling Fig. 47 the flanges are made in segments so that one fits into the other. In the figure, segment *A* connects to one hub and segment *B* to the other. The segments are separated by rubber cylinders held by two steel rings locked in place on the inside of the rim. Power is transmitted through the rubber cylinder, which also absorbs load shocks. A modification of this design is shown in Fig. 48. Here springs are the resilient member. This coupling has five arms on each

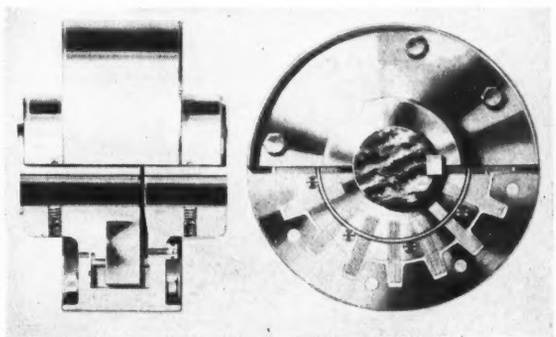


Fig. 50—Laminated-steel spokes form the connection between the two halves of the coupling

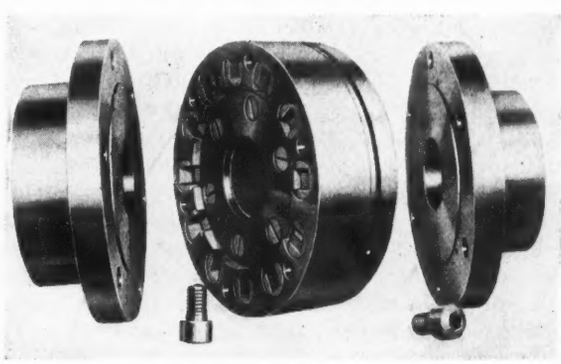


Fig. 51—Coupling designed for high-speed service

hub. One end of each of 10 springs is attached to the arms on one hub. The other ends of the springs are attached to the arms on the other half. Power is transmitted from one hub to the other by compression and tension of the springs. Five of the springs are in compression and five in tension in each direction of rotation. The spring assembly consists of two clamps, two plugs, and one spring. The plugs are inserted in the springs, the clearance between the ends of them being slightly less than the maximum permissible deflection of the spring, so that an excessive overload will bring the plugs together before the springs are completely compressed.

Construction of another type of spring coupling is shown in Fig. 49. One hub has a rim on the periphery of its flange, inside of which are five short arms. The other hub has five arms with slots in the ends, in which the arms on the inside of the rim fit. Thus the arms on the two halves of the coupling interlock. Springs in which are inserted case-hardened bearing plugs are placed between the arms to retain the two halves of the coupling in interlocked relation. The coupling is packed with cup grease to minimize wear on all contacts, and power is transmitted through the springs. All working parts are inclosed in a cylindrical case, which makes it a safety-type unit. Clearance between the two halves of the coupling is sufficient to take care of usual end play of a motor shaft. The couplings in Figs. 47 to 49 are flexible in all directions and are made in medium and large sizes.

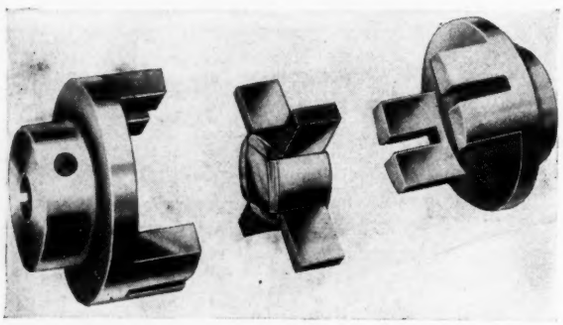


Fig. 52—A laminated-steel cross connects the two halves of this coupling

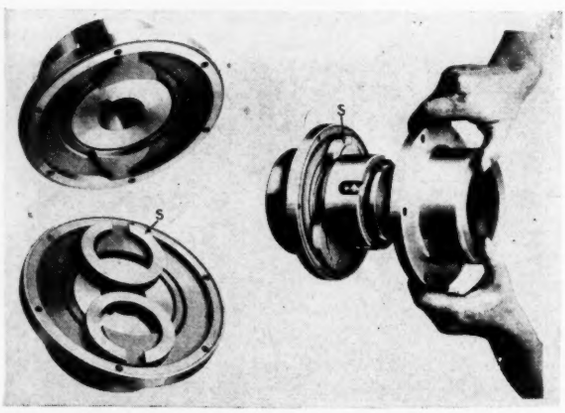
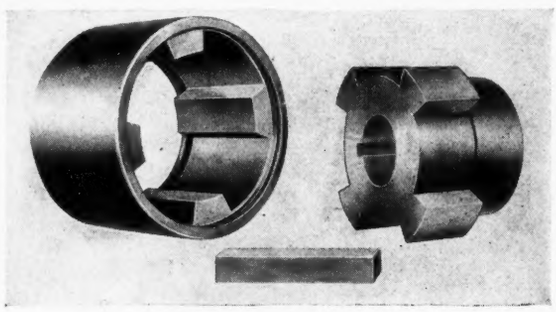


Fig. 53—Ring-shaped springs provide tangential flexibility

In Fig. 50 the coupling is made on the principle of an internal and external gear, the latter with teeth that are resilient. In the rim of one hub are laminated-steel spokes. On the other hub there is a rim with slots cut on its inner periphery. The laminated spokes on one hub fit into the slots in the other. The flexible spokes give the coupling tangential flexibility. These couplings can be designed to take care of end play up to 6 in. They are entirely inclosed, and are partly filled with a lubricant.

The coupling in Fig. 51 is designed for high speeds. Hubs are made separate from the center section of the coupling, which consists of an internal and an external part. There are a number of laminated-steel spokes or pins in the internal part. In the outer ring are cut circular notches in which are placed hardened-steel bushings. The bushings are slotted to receive the end of the laminated spokes in the inner ring. This coupling is lubricated with grease or oil, depending on operating conditions. All movement is between hardened-steel parts. The two hubs bolt to the center section, which can be removed from between the hubs for inspection without interfering with either the driving or driven shaft. Fig. 52 is a coupling that is intended for small power drives. Two similar flanges are connected by a center cross made of laminated spring steel.



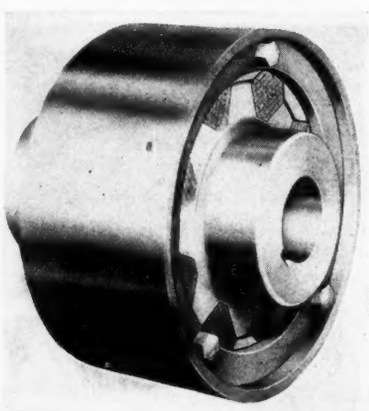


Fig. 54—Pieces of square packing connect the hubs with the cylindrical member

Fig. 55 — Internal and external hubs are connected by square leather keys

A full-floating, semi-universal joint coupling is shown in Fig. 53. The parts of the hub keyed to the shafts are sleeves with four radial pins. The hubs fit into sleeves slotted at one end to receive the pins in the hub. On the other end of the sleeves are radial arms, the ends of which fit in between the ends of ring-shaped springs *S*. This type is constructed of steel throughout, is operated lubricated, and is flexible in all four directions.

There are on the market a number of coupling types that have projections on the hubs and on the rim between which flexible keys are placed. One of these is shown in Fig. 54. Each of the hubs has projections on it as shown on the one in the figure. These fit in between the inward projections on the inside of a cylinder. Projections on the hub are held central between those on the cylinder by a piece of packing on each side of them. Standard hydraulic packing, kept on hand around most plants, is used. The packing is held in place by a spring retaining ring. No bolts or screws are used, and remov-

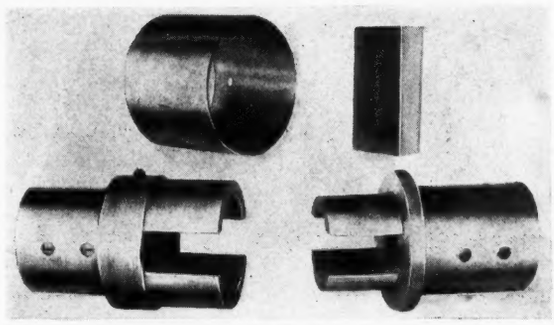


Fig. 56—The two halves of the coupling telescope and are held by a single leather key

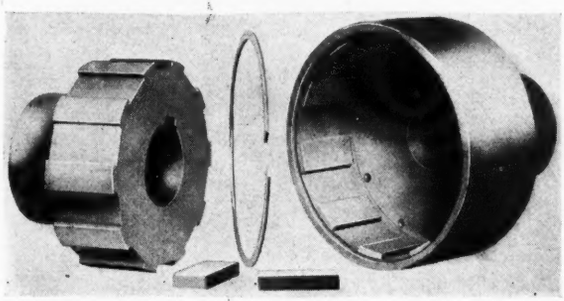


Fig. 57—Multiple-leather-key type coupling

ing the spring retaining ring allows the coupling to be readily dismantled.

The coupling in Fig. 55 has a rim with the inward projections cast as a part of one hub. The projections on the other hub have a diameter less than that of the projections on the rim. When the coupling is assembled the projections on the two parts of the couplings are lined up and are held in place by rectangular pins made of special leather or other material of high elasticity and good wearing qualities. The coupling is so designed and assembled that the two halves are insulated from each other.

What is known as a single-key coupling is shown in Fig. 56. It is made of two cast-iron hubs with slotted cylindrical projections. Projections on one hub fit inside those on the other. A single radial leather key in the slot is held in place by a steel tube sleeve that covers the union of the two couplings and is held in place by a screw. This coupling is built in small capacities only.

Fig. 57 shows a type that is made in medium and large sizes. On one hub is a cupped flange with slots cut in its inner periphery. The other hub has slots cut in its outer rim. Leather keys in these slots are held in place by a snap ring. The leather keys form the flexible and wearing parts. These can be easily replaced when they become worn or damaged.

MANUFACTURERS OF THE TYPES OF COUPLINGS SHOWN IN THE FIGURES

Fig. 35—Flexible steel disks, Thomas Flexible Coupling Co., Warren, Pa.
Fig. 36—Links and disk.....The Meriam Co., Cleveland, O.
Fig. 37—Thermoid disks, Philadelphia Gear Works, Philadelphia, Pa.
Fig. 37—Balata disks.....Aldrich Pump Co., Allentown, Pa.
Fig. 37—Leather disks, Falls Clutch & Machinery Co., Cuyahoga Falls, O.
Fig. 38—Rubber disk, Ajax Flexible Coupling Co., Westfield, N. Y.
Fig. 39—Gears and Forgings, Cleveland, O.
Fig. 40—Leather links..Bruce-Macbeth Engine Co., Cleveland, O.
Fig. 41—Steel-wire links, Bruce-Macbeth Engine Co., Cleveland, O
Fig. 42—Gear, double engagement, Poole Engineering & Machine Co., Baltimore, Md.
Fig. 42—Fast.....Bartlett-Hayward Co., Baltimore, Md.
Fig. 43—Telescopic.....General Electric Co., Schenectady, N. Y.
Fig. 44—Silent chain.....Morse Chain Co., Ithaca, N. Y.
Fig. 45—Roller chain, Diamond Chain & Mfg. Co., Indianapolis Ind.
Fig. 46—The Meriam Co., Cleveland, O.
Figs. 47 to 49—Nuttall, Westinghouse Electric & Mfg. Co., Pittsburgh, Pa.
Fig. 50—Brown Engineering Co., Reading, Pa.
Figs. 51 and 52—Smith & Serrell, Newark, N. J.
Fig. 53—T. L. Smith Co., Milwaukee, Wis.
Fig. 54—The Medart Co., St. Louis, Mo.
Fig. 55—The Clark Controller Co., Cleveland, O.
Figs. 56 and 57—General Electric Co., Schenectady, N. Y.

Control Improved for Feeder Voltage Regulators

TWO single-phase induction feeder voltage regulators are often used in a bank of two to regulate three-phase, three-wire alternating-current circuits. One of the conditions for maintaining correct voltage at the center of distribution is that the current in the line drop compensator is of the correct power factor in relation to the line-to-line voltage.

Line current of a three-phase, three-wire circuit is 30 deg. out of phase with the line-to-line voltage when the power factor of the system is unity. Under this condition the current in the compensator would be 30 deg. out of phase with the voltage obtained from the secondary of the potential transformer if one current transformer were used with each compensator. To correct this it has been standard practice for many years to use three current transformers with two regulators, the secondaries of the current transformers being interconnected to correct the phase angle in the compensator circuits.

Modern outdoor-type regulators are usually equipped

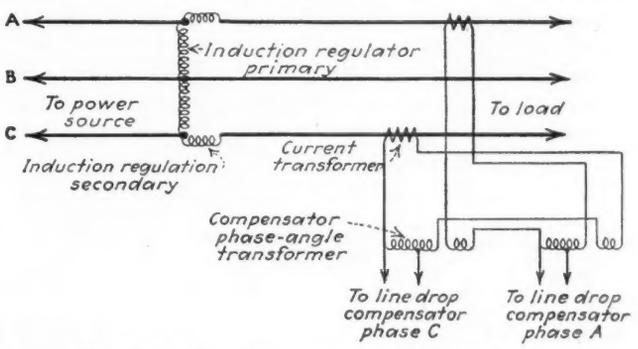
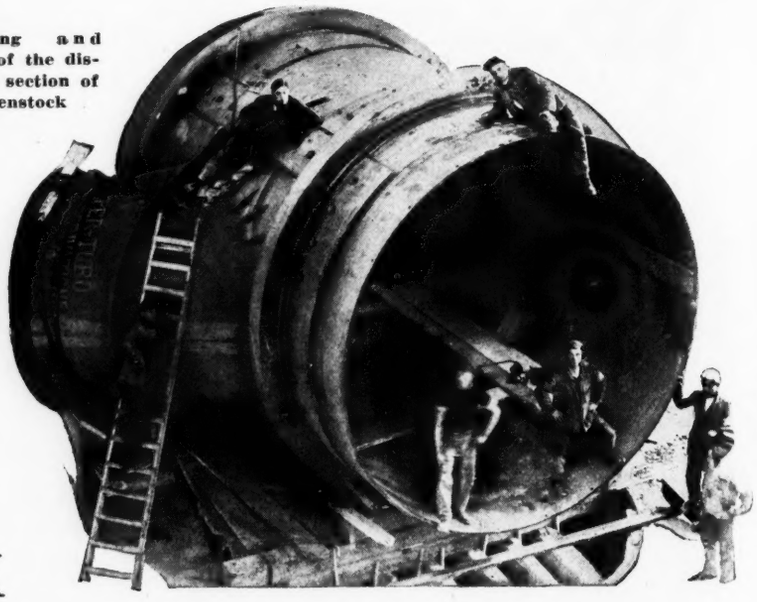


Diagram of induction regulator and voltage-drop compensator connections

with current and voltage transformers mounted inside the outdoor hood. The use of three-current transformers for this type of installation made it necessary for the purchaser to mount the extra current transformers separately from the regulators or purchase a specially designed regulator with two current transformers mounted inside the hood.

Recently a new arrangement of connections, to eliminate the need for the third current transformer, has been developed by the Westinghouse Electric & Manufacturing Company. There is a small phase-shifting current transformer in the secondary of the current transformer circuit for each regulator, as in the illustration.

The phase-shifting transformer or compensator phase-angle transformer, as it is usually called, can be made quite small, since it need be insulated only for the secondary circuit and its volt-ampere burden is small. It may be a separate transformer that can be mounted conveniently on the rear of the standard regulator accessory panel, or it may be incorporated as part of the compensator.



Assembling and welding of the distribution section of the penstock

WELDED PENSTOCK

Used in Italian High-Head Project

The penstock for the Galleto hydro plant in Italy is 13 ft. diameter, and is designed for a 630-ft. head. The upper section is made of mild-steel plate, and the lower section of nickel-steel plate. It is electrically welded throughout. After installation and testing, reinforcing rings were applied to the bends by welding

By R. W. MILLER
Engineer
Arolsen, Germany

IN UMBRIA, near Rome, Italy, a large water-power station, known as the Galleto plant, has been constructed on the River Velino. This station is part of a plan to combine 23 old water-power plants on the Velino and Nera rivers into a modern project. Water required for the Galleto plant, amounting to 6,355 cu.ft. per second, is taken from the Velino River above the Marmore Falls. From the intake the water flows through an open channel 2,310 ft. long x 56 ft. deep, and then through a concrete tunnel 2,410 ft. long and 24 ft. diameter to two surge chambers, Fig. 3. From the surge chambers two penstocks 13 ft. in diameter lead down to the power station.

One of the penstocks, lined with steel plate, is now in service. The other has been driven through the rock and will be completed at a later date. Both penstocks descend to the valley of the Nera at an angle of 50 to 66 deg. The head is approximately 630 ft. A horizontal section at about the middle of the penstocks was necessary to avoid a large fault in the rock which was partly filled with loose material. The horizontal portion of the pipe line was led into the open and re-entered into the mountain at a bend. In the Galleto station the penstock connects with the distributing pipes for the four turbines. The pipe line has a diameter of 13 ft., and the distributing pipes a diameter of 5 ft. The distance between the branches is 33 ft., so that the complete distributing pipe line, including the inlet bend, is approximately 165 ft. long.

Thickness of the plate in the penstock varies from 0.4 in. to 1.25 in., according to the pressure and the strength of the rock. The upper part of the penstock, above the horizontal section, is made of mild-steel plate from 0.4 in. to 0.64 in. thick. The horizontal part and the lower inclined portion are made of nickel-steel plate from 0.75 in. to 1.25 in. thickness. Branch sections in the penstock are made of cast steel.

The penstock was constructed of plate sections 6.5 ft. long, and two sections were united in the shop to form a 13-ft. pipe, which was transported to the site. The girth seams are lap welded, and the longitudinal seams butt welded and reinforced with double straps. During assembly individual pipe sections were unloaded on the road above the precipice and lowered through the tunnel into position and welded together. Bends were partly assembled in the shop and transported to the site and welded together. While the penstock was being assembled the space between it and the rock was filled with concrete, the pipe being secured against deformation by reinforcing crosspieces.

Manufacturing and mounting the large shrink rings, 12x8 in. cross-section, used to connect the cast-steel branch pieces to the pipe line, above, was especially interesting. The largest one of the rings, 13 ft. in diameter, was forged in two parts, which were joined by an electrically welded dovetailed joint. After putting

the rings in place hot, welding was completed on that section of the distributing pipe line.

Tests and tension measurements were made on the finished penstock at a pressure equal to 1½ times the normal operating pressure. In view of line's large dimensions, and because of the use of nickel steel and electrical welding, great importance was attached to the careful measurements (with Huggenberg tensometers), especially of the distributing section and inlet bends. The object was to ascertain the distribution of tensile stress in those pieces which did not lend themselves readily to exact calculation. The measurements were also prompted by the fact that with nickel steel of high strength, and correspondingly less elongation, compensation of local tensile stresses does not take place so readily as with a less rigid material. The tests proved what had been surmised, that high local stresses prevailed.

For these reasons the distributing section and the upper bend in the penstock were reinforced after installation and testing. This reinforcement consisted of circular straps welded in steps to relieve the corner straps of the bend. In Fig. 1 rings *A* were installed as part of the pipe line. After testing, the stepped rings were added. The inner side of the corner strap joints of the two bends was also reinforced by straps. These reinforcements were easily applied to the electrically welded pipe and they were also electrically welded in place.

The whole process proved that electric welding permits of subsequent reinforcement of parts which have been found by exact investigation to require strengthening. The inner corner straps used in conjunction with electric welding have also proved to be a practical means for the subsequent reinforcing of welded objects. A sinimar method of reinforcing a riveted vessel of such dimensions would have been impossible. As may be seen from Fig. 1, the circular straps added later did not impair the appearance of the construction.

The complete penstock was executed according to the plans of Escher, Wyss & Company in collaboration with the Societa Terni, in whose steel works in Terni the plate and the penstock sections were manufactured. Assembly of the penstock sections and of the distributing pipe line in the Terni works was supervised by a staff of Escher, Wyss engineers, as was assembly and welding of the pipe at the power plant. The pipe line has been in service since the spring of 1929, at first with one 50,000-hp. turbine and now with three such units.

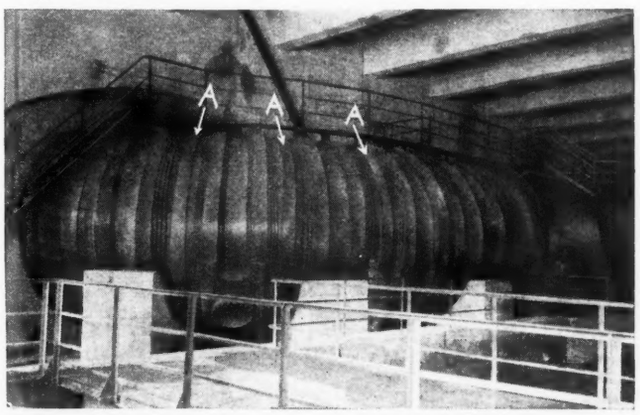


Fig. 1—Inlet bend of distribution section of the penstock after reinforcing rings have been applied. Rings *A* are those that were installed with the pipe

Fig. 2 (Above)—Assembly of penstock in shops. Distribution section on the right, with one of the cast steel branch section in place

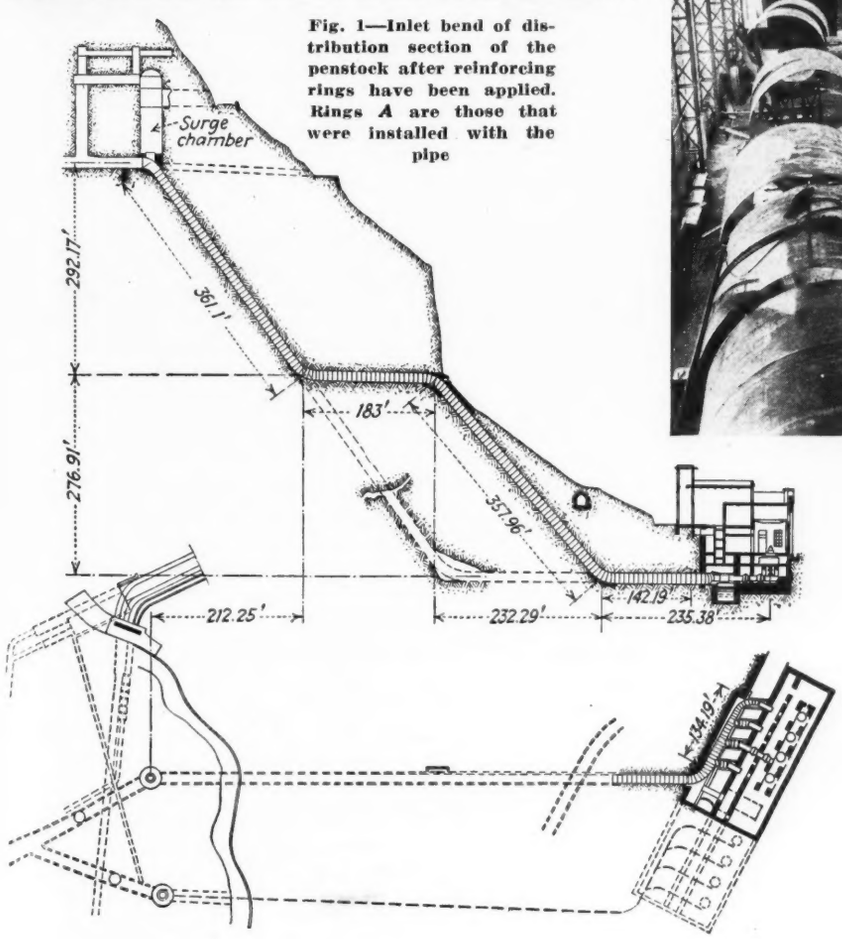


Fig. 3 (Left)—Plan and elevation of one of the penstocks. It was originally intended that the penstock should follow the dotted line shown in the elevation, but to avoid the fault in the rock the horizontal section was put in about the middle of the pipe line

FATIGUE CRACKS AND BOILER PLATE

Fig. 1—Corrosion-fatigue crack from test specimen; x 63[1] (steel 0.25 per cent carbon; quenched and drawn; stressed 13,000 lb. per sq.in. for 10 days in fresh water)

By CAPT. C. H. DINGER, U. S. N.
Engineering Experiment Station, Annapolis, Md.

Studies of "fatigue corrosion" throw new light on boiler materials. Points subjected to overstress, periodic variations and corrosion, limit the strength of the entire drum. Design should therefore be based on the stresses at these points and on the corrosion fatigue limits of the metal used

WITH the coming of higher steam pressures and the desire to keep down the weight of pressure parts, it is natural to seek stronger boiler-plate material than that ordinarily used, and sometimes to permit a considerable stress concentration, overlooking the possible formation of corrosion-fatigue cracks.

In the search for materials of greater strength, nickel and other alloy steels and specially made steels have been proposed, usually because of certain higher physical characteristics and somewhat better corrosion-resistant qualities. However, if consideration is given to fatigue and corrosion fatigue, the use of material of high tensile strength may not necessarily mean a more durable boiler shell or drum. Nor will a hydrostatic test insure dependability.

An essential criterion of the durability of boiler-plate material is its behavior under corrosion fatigue, where the material is subject to the action of the steam and boiler water. The corrosion-fatigue limit does not vary in accordance with tensile strength or elastic limit, but appears to be about the same for all carbon steels. Certain non-ferrous materials, such as copper, nickel, and chromium, when present in conjunction with other materials, may raise the corrosion-fatigue limits. The effect of heat treatment is lost under conditions of water corrosion-fatigue. We may then have the condition where a material of comparatively high tensile strength has no better corrosion-fatigue resistance than plate of much lower tensile strength. For temperatures above 700 deg. consideration must also be given to "creep," a subject receiving considerable attention at the present time.

The table on page 876 gives the physical characteristics and fatigue limits of various materials that might at present be considered for use in the construction of high-pressure boilers, as well as of stainless steels and some non-ferrous materials having good resistance to corrosion fatigue. These data are taken from the results developed at the United States Navy engineering experiment station, Annapolis, Md., in connection with investigation of the general problem of fatigue of metals.

The question of obtaining lighter pressure parts, where they are subject to fatigue and corrosion fatigue, becomes a problem of design, wherein fatigue characteristics are essential factors. The fatigue endurance limit of any material is generally well below the elastic limit, and sometimes very much below. If the fatigue properties of the material are known, the factors of safety can be applied more intelligently; in fact, a margin of 25 per cent below the endurance limit is a better factor of safety than 5 on the tensile. In some instances a factor of 5 on the tensile may be above the fatigue endurance limit, and hence unsafe. However, it would be in order to design according to the ordinary method, provided that the fiber stress allowed for any particular material by such rules of design was well below what the apparent corrosion-fatigue limit would indicate to be safe.

Furthermore, for equal strength, parts subject to the presence of water will have to be made heavier than those subject only to the action of steam or air, and those parts where stress concentration is produced from any cause or which are subject to repeated alternation or reversal of stress must be made somewhat heavier than those subject to static, constant, or definitely known loads. The shell plate of a cylinder can have a calculated

[1]Here, as in remaining illustrations, gives final magnification as printed.

fiber stress somewhat higher than a plate bent to form a knuckle where variable and uncertain stress concentration may take place.

Lightness is to be secured by removing the metal from the parts where it is not really needed and putting it on to the parts that may be repeatedly stressed beyond the fatigue limit, where the stresses are uncertain, and where stress concentration may take place. Hydrostatic tests will disclose the weak points due to pressure, but knowledge of corrosion-fatigue limits will locate additional weak places that may fail in service.

Use of seamless drums or welded drums will eliminate riveted joints, usually the weakest part of boilers. However, this will not avoid fatigue cracks if sufficient stress concentration is present in any part. If the tube ligaments are overloaded, they will develop fatigue cracks, and if heat expansion causes distortion or flexure, fatigue cracks may be formed at any point where stress concentration may be present. However, welded or forged drums are likely to be much safer than riveted drums, because one of the principal sources of weakness has been eliminated.

In parts of boiler drums or shells where knuckles are formed changes in contour take place. Where complicated stress concentrations may occur in the presence of water the design should allow large safety factors at points of stress concentration or where stress is uncertain. In most cases this will add but little to the total weight, but will make the vessel safe indefinitely under operating or test pressures.

The information here developed would indicate that the ordinary formulas for boiler design where factors of safety of 5 to 6 are allowed, thus allowing for fiber stress from 9,000 to 12,000 lb., do not carry a large margin on the corrosion-fatigue limit for fresh water, which for ordinary boiler plate is 13,000 to 16,000 lb. The failure will, of course, take place at points of stress concentration where the actual factor of safety is low, particularly where repeated bending or flexion takes place. The presence of water containing mineral salts, such as sea or brackish water, reduces the corrosion-fatigue limit, and a similar effect will be experienced

Fig. 2—Corrosion-fatigue pit—the beginning of a crack (8,000 lb; 10 days; fresh water)

from certain hard or alkaline waters where the chemical ingredients may cause an acceleration of damage.

The corrosion-fatigue limit varies for different solutions in contact with the metal. There is a considerable difference between fresh water and salt water. Steam vapor has less effect than fresh water, but the actual amount has not been determined. Strong alkalis no doubt have an important effect upon the corrosion-fatigue characteristics of boiler plate, and it is believed likely that the caustic embrittlement phenomenon is but one manifestation of corrosion fatigue.

Certain chemicals other than the salts of sea water will

Fig. 3—Corrosion-fatigue crack from knuckle of a boiler drum casualty; x 36

affect, in a varying degree, the action on the boiler-plate material. It will therefore be seen that the actual durability of boiler-plate and tube material may be varied materially by the chemical content of the water or gas it contains, and that this effect (corrosion under stress) is materially different from ordinary surface corrosion.

Bad effects of certain chemicals may perhaps be neutralized by the addition of inhibitors when information on these points is available, but that information being more or less uncertain, the safest thing is to avoid, where possible, the presence of the ingredients or the conditions that have a destructive effect. Use of the proper sulphate-carbonate ratio on feed waters having a tendency to cause or accelerate so-called caustic embrittlement appears to be quite sound, as is also the practice of using pure and uncontaminated feed waters, and of reducing oxygen in the feed water.

A boiler plate that is safe when repeatedly stressed in the presence of air may be unsafe when subjected to steam. One safe for steam may be unsafe when in contact with fresh water; while one that is safe for fresh water may not be safe for salt water or certain alkaline waters.

Nor are these differences of small order. Corrosion-fatigue limits of certain steels are substantially different for air, fresh water, and salt water. If the nature of the service that the vessel is to be put to is known, these differences can be appropriately allowed for in the design.

"Caustic embrittlement," very likely a particular manifestation of corrosion-fatigue, is the term applied to fatigue cracks produced with feed water having a certain alkaline content and condition. Corrosion-fatigue tests might be made of specimens subjected to various kinds of boiler water, and these would then show the comparative effect of the varying ingredients, and of any inhibitors that might be used. If this were done we would then have data not only upon the endurance properties of the metal used, but also on the conditioning of feed water that will secure the highest endurance limit of metal actually in use.

Pressure vessels containing gases and other liquids offer still another problem which also can be simplified by consideration of the corrosion-fatigue properties of the stressed metal in the presence of particular gases or liquids.

Machines for testing specimens in the presence of gases and poisonous liquids will be somewhat more com-

plicated and expensive, but there are no insurmountable difficulties in producing them. These need be used only to determine difference of effect between running temperature and room temperature, since it may be found that change of action due to temperature is not great.

A series of corrosion-fatigue tests on specimens subjected to various solutions and gases that may be encountered in service would then indicate not only the safe working stress, but also the varying effect of the different media and of any inhibitors that might be tried out. In this way positive information could be developed in a comparatively short time that would help insure safe design for pressure vessels subject to liquids or gases which may have special corrosion-fatigue reactions on the metals used. These results might clear away some of the uncertainties attending the use of pressure vessels, such as boilers, stills, and special chemical or gas containers.

Investigation of corrosion-fatigue cracks in boiler drums brings up the following observations:

Intermittent stress concentration, if carried on long enough, will produce fatigue cracks in boiler plates below the water line. These cracks will appear first at points where stress concentration is present.

The cracks can be initiated at stresses well below the elastic limit, but apparently fiber stress not exceeding 10,000 lb. for steel will not form such cracks in a reasonable time. Experience indicates that a stress concentration of 15,000 lb. or more may result in eventual failure during the expected life of a boiler, say twenty years.

Fig. 4 — Corrosion-fatigue pit or crack (incipient failure) in boiler-tube sheet of U.S.S. McCawley; x 23

If water is kept away from the part where stress concentration is present, the damage is much less rapid, since the stressed metal will then operate substantially as ordinary fatigue in air.

Character of the water will cause considerable difference in progress of the cracks. Salt water is much more destructive than fresh; apparently any water likely to cause material surface corrosion will also accelerate corrosion-fatigue action. It is not unlikely that oxygen content of the water and its circulation will be a material factor in speeding the action.

A corrosion-fatigue crack is sometimes distinguished from a "caustic embrittlement" crack by the fact that it is not entirely intercrystalline and that corrosion products are more in evidence. Corrosion-fatigue cracks in actual boilers

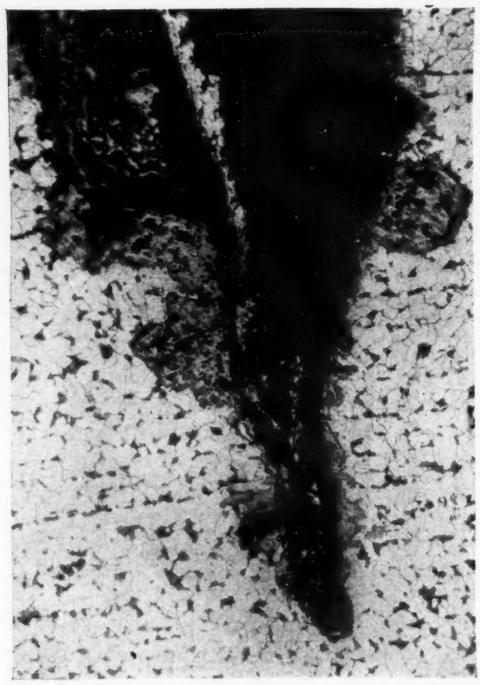


Fig. 5—Tip end of crack shown in Fig. 4; x 83

are substantially the same as those appearing on specimens at room temperature and on propeller shafts.

These cracks are accelerated by the mere presence of moisture, and their rate of progress is dependent upon the stress range, time, and number of cycles. They have been formed where no caustic was present and in overstressed parts other than seams. Their appearance in numerous boilers and their resemblance to shafting cracks and the cracks produced in test specimens indicate that they are of similar nature and are produced by similar causes. They appear where stress concentration is present from any cause. Water in contact accelerates the action.

Since oxygen and moisture are necessary to produce corrosive action, it may well follow that the rate of damage is somewhat dependent on the amount of oxygen present in the water. A low oxygen content may mean a finer, or perhaps, intercrystalline, crack; while an abundance of oxygen may mean a wider and partly transcrystalline crack. The stress range used, and time also, may perhaps affect the character of the crack.

Fatigue cracks formed in boiler material, whether intercrystalline or otherwise, are always produced at points of stress concentration, and in most cases where some repeated bending action has been produced due to expansion or contraction of the part, to vibration, or to the natural tendency of some part to change its shape with the application and release of pressure. Cases have been found where corrosion-fatigue cracks resulted from stress concentration produced by a handhole dog being set up excessively on a cross box, by cross boxes being bent sideways, by expansion, etc.

Stress concentration can be produced in many ways. In a riveted joint it can be produced by too high pressure in forming rivets, by plates not fitting properly, by burrs left between the joints, by having rivets force plates into position by bending below the elastic limit. When the highly stressed area is in contact with boiler water, formation of cracks is accelerated. Crack formation is influenced also by the condition of the water.

This seems to teach that: Rivet hole cracks may be

accelerated if water has access to the edge of hole next to the inside of the plate, where great stress concentration may be present. This entrance of water may be avoided by inside calking or some other method of sealing the inside edges of all plates. Making up joints with some coating that stays on under boiler conditions may be desirable. It is also important that excess riveting pressures be not used and that inside rivet heads be tight.

The condition of water may be important, but the real point in connection with a riveted joint is to keep the water out of the joint. If this is done, we have prevention, and if any boiler drum is tight with inside calking alone that drum is not likely to experience fatigue cracks in rivet holes.

Another essential is to avoid stress concentration in the design, in workmanship, or by reason of operating conditions, such as movement due to differences in temperature, etc.—in other words, anything that tends to localize and concentrate stress or produce intermittent

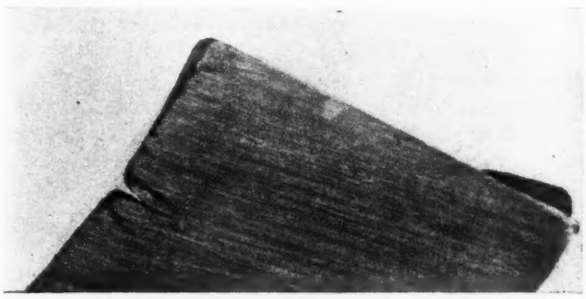


Fig. 6—Specimen showing crack in the section; x 2

or repeated stress concentration. Such stress concentration may be produced by improper design of parts, also by poor workmanship. These may be aggravated by operating conditions.

Water conditioning is an essential factor. It will be more effective when we have learned somewhat more definitely what the ingredients are that accelerate or retard corrosion fatigue. Indications are that pure condensate, deaërated and made slightly alkaline, with a pH value between 9 and 10, is probably the least harmful; that water containing salts in a proper state of equilibrium may also be fairly harmless; and that water which will produce, continuously, a protective film will be safe. A protective coating may be of considerable help.

At present the inhibition of caustic embrittlement cracks seems to be predicated merely on the carbonate-sulphate ratio and on the concentration of caustic. This undoubtedly is a factor, but stress concentration and oxygen certainly are factors also. The apparent result that all the ordinary steels have the same corrosion-fatigue resistance should receive consideration; since, if this is actually true, the high carbon, high-tensile steels would have but little advantage for use in boiler drums.

Riveted joints should be inside-calked, and sealed in any practical way to keep out water. A slight amount of scale in old boilers has doubtless acted to protect these joints; that is why some old boilers last so long.

The designed fiber stress should, for real safety, not be over 10,000 lb. per square inch. A stress of 15,000 lb. may serve sometimes, but it does not give much margin for possible defects. Many boilers designed on a nominal basis of 10,000 lb. have developed fatigue cracks that were not looked for, because of stress concentration unexpected and unallowed for. Neither can ideal water conditions be constantly maintained under operating conditions. So-called caustic embrittlement, that is, intercrystalline fatigue cracking induced by improper ratio of sulphate to carbonate in the feed water, is no doubt an actual phenomenon. It should not, however, be employed as an "alibi" for bad design and poor workmanship which have permitted improper stress concentration to form corrosion-fatigue cracks, or which may have initiated the hidden cracks during the fabrication of the drums by too high riveting pressure, working plates at blue heat, drifting rivet holes, improper calking, etc.

A thoroughly well made, properly designed boiler drum is not likely to fail from caustic embrittlement alone. The navy operated many boilers at 3 per cent alkalinity for years with no instance of caustic embrittlement. I do not believe there has been a real case of caustic embrittle in any navy boiler. Where cracks have been found, they were accounted for by other reasons. We have had plenty of fatigue cracks.

Initiation, progress, and growth of corrosion-fatigue cracks is now pretty well known. The first action is a shallow pit, probably at some point of local weakness, a scratch, nick, or inclusion in the area of stress concen-

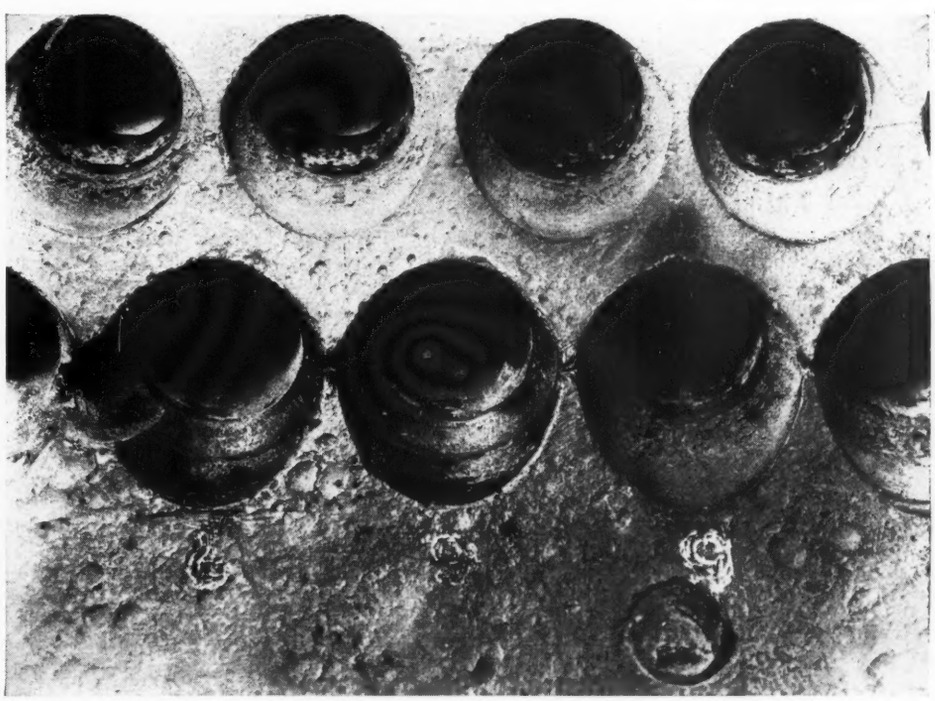


Fig. 7—Part of an express boiler tube sheet showing cracks in ligaments where they were counterbored to allow for belling of tubes; x 0.82. Note that ligaments in adjacent row are quite sound

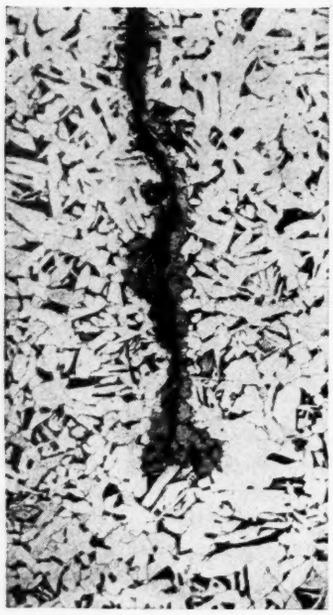


Fig. 8—End of corrosion-fatigue crack shown in Fig. 3; x 70

tration (see Fig. 2). This pit gradually becomes deeper. Then a hair-line crack starts and progresses as a channel having almost parallel sides. The metal affected by corrosion forms banks and islands in the channel, the whole resembling a bird's-eye view of a sluggish tidal stream or estuary.

At the extremity of the crack there is usually a spear head, and here is where the destructive work is done. The water having access to the crack supplies the moisture and oxygen, the intermittent stress probably breaks the oxide film on the surface, and then the air and moisture attack the metal, forming an oxide which is again broken; thus the action goes on.

Waters containing certain cleansing salts probably have a more destructive effect than other waters. Certain chemicals may act more on the crystal boundary, and others more on the surface of the crystal. The amount of oxygen present probably affects the action.

If the cyclic stress is sufficiently large, the damage proceeds, and the only way to prevent it would appear to be to stop the formation of the original pit, which would mean a lower stress range and absence of or protection from the corroding medium. Remove the water, protect the surface, lower the stress concentration, or, perhaps, remove the air from the water, in order to circumvent this particular devil. When the action is analyzed, it really is not so mysterious: It is just nature taking advantage of an environment.

It should be emphasized that these pits and cracks can be started by stress very much below the elastic limit.

Studies of the effect of corrosion-fatigue damage in a considerable variety of steels show that the rate of damage is little affected by chemical content or physical properties.

The table shows values for a variety of materials. It will be seen that Monel metal and, in general, copper-nickel materials, do not lose much by the presence of water, and also that a change from fresh to salt water makes little difference.

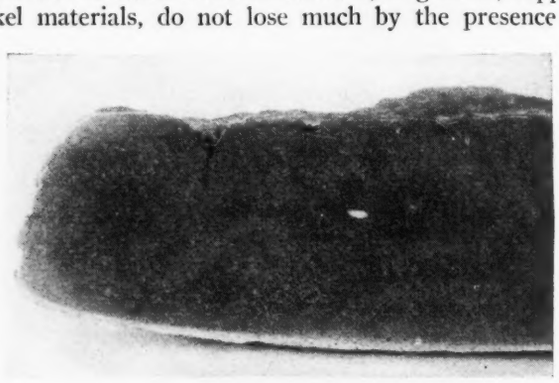


Fig. 9—Same crack, normal size

FATIGUE LIMITS FOR VARIOUS MATERIALS

Material	Tensile Strength Lb. per Sq.In.	Rotative Cantilever Test — Endurance Limit, Air, Lb. per Sq.In.	Rotative Cantilever Test — Corrosion-Fatigue Limit, Lb. per Sq.In., Fresh Water	Rotative Cantilever Test — Corrosion-Fatigue Limit, Lb. per Sq.In., Salt Water
0.16 per cent carbon steel	52,000	25,500	17,500	6,000
0.24 per cent carbon steel	55,600	24,000	17,000	.....
1.09 per cent carbon steel	103,400	42,000	21,000	8,000
3.7 per cent nickel steel	130,400	62,000	22,000	8,000
Monel metal	127,200	52,000	23,000	26,000
Monel metal	81,900	36,000	24,000	26,000
Duralumin	54,600	11,000 to 13,000	7,000 to 9,000	6,000 to 8,000
Stainless steel	178,000	88,000	32,000	.....
Stainless steel	117,400	53,000	37,500	27,000
Stainless steel	94,400	52,000	36,000	36,000

The corrosion-fatigue limit given above is an indication of durability. It can be used as a guide in design.

These particular materials probably form real protective films which cause them to have practically the same strength in water as in air. This indicates, in the writer's opinion, that Monel metal and stainless steels would be good materials to use for boiler drums if they were not so expensive.

However, if steel boiler plate is used the design should be such as to avoid any possibility of areas of stress concentration in the presence of water. Bending action, due to changes in temperature from any cause, should be avoided.

Safe water should be used, and it should be as free from air as possible.

Novel Means for Improving Power Station Output

AN INTERESTING means of improving the average output of electric generating stations working with steam power has recently been described by M. Mathivet, chief engineer of the Noeux mines in the north of France. He proposes to utilize a process of hydraulic equilibrium which will enable boilers and turbines of the power station to work constantly at a level of economic efficiency instead of being subject to great fluctuations between the hours of peak loads. This process, which has already been tried in Germany and Switzerland, requires the construction near the power station of two large reservoirs of water, one on a lower level than the other.

When the load demand on the station falls off the surplus power is used to drive centrifugal pumps which fill the upper reservoir. During the hours of heavy load the water is allowed to flow back to the lower reservoir, regenerating power by hydraulic turbines. In M. Mathivet's opinion, this system applied to the central power stations of the Paris area would economize 300,000,000 to 400,000,000 kw.-hr. a year, representing a saving of at least $800,000.

He believes that the process could also be utilized in the mining area of the north of France by taking advantage of the depth of the 200 pits in that district. As the pits have an average depth of more than 1,500 ft., the reservoirs needed might be comparatively small, both at the pit head and at the bottom of the pit. For example, with a 1,000-hp. system of hydraulic equilibrium for each pit, M. Mathivet considers that 200,000 hp. could be obtained for the mining area and that the reservoir at the bottom of the pit would need a capacity of not more than 140,000 to 175,000 cubic feet.

. . . RIGHT OUT OF THE PLANT . . .

Valve Stem Troubles and How to Overcome Them

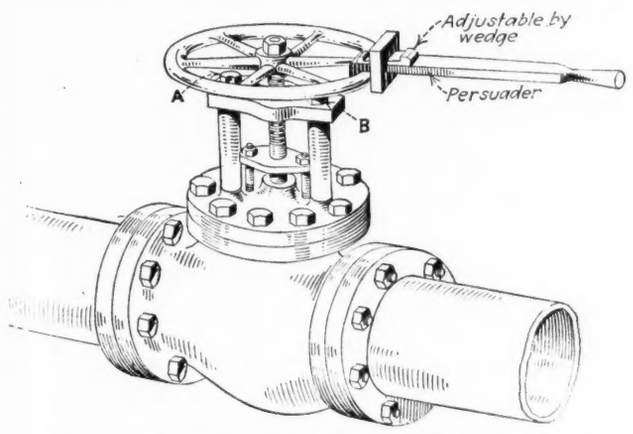
AN INTERESTING subject that as a reader of *Power* I should like to see discussed is valve-stem troubles and their remedy. In almost every plant these troubles exist to some extent, and even if they have been discussed before in print they are still with us and perhaps new ways for their prevention or cure may have been found but not passed along for the benefit of others.

Recently I was forced to cut out a section of the plant long enough to take down a line stop valve to free the stem and put it in working order. This required several hours and was costly.

Our plant rules require that these valves be gone over at regular intervals, that is, operated to ascertain that they are in good working condition. In spite of the rules and an endeavor to enforce them, troubles crop up, and are excused on the plea of multiple duties that make one negligent on such tasks as valve inspection. The troubles are, of course, confined to the valves least used.

How do other plants take care of this situation?

When I find a valve has become seized at the stem I first try to free it by working it with a bar (commonly termed a persuader) attached to the wheel, as indicated



Use of collar and wedge makes extension bar adjustable to several sizes of valve wheels

in the sketch, being careful not to twist it so severely as to distort the thread pitch or otherwise damage the stem. If the stem cannot be moved with the persuader, then the threads are cleaned and soaked with kerosene and the yoke is heated to expand it, and the persuader is again tried, working the stem in and out a little and cleaning it at each move.

Failing to get results in this manner the valve is taken apart and removed to the shop for freeing. In the shop it is bolted to a suitable angle plate and a wrench put on the stem just under the head or bonnet flange, and the persuader is applied to the wheel and another attempt made to free it with the double leverage. If this attempt fails the stem has to be cut off and drilled out and a new one made.

When valves are closed under normal pressure and temperature, and the line is permitted to cool down, it is frequently found upon attempting to open the valve again that it is stuck tight. Slacking off the yoke stud nuts *A* and *B* will relieve this strain. The valve will then move easily, the nuts on the yoke being tightened when the disk is free from the seat. C. H. WILLEY.

CONCORD, N. H.

Increasing Load on Low-Pressure Cylinder of Compound-Engine

THERE has been considerable discussion in *Power* as to the method of increasing the load on the low-pressure cylinder of a cross-compound engine in relation to the load on the high-pressure cylinder. For the benefit of readers who might be somewhat confused by the several methods discussed, I should like to add the following comments.

In the original question, which appeared in the Nov. 12, 1929, number, the editor said that increasing the high-pressure cutoff would do it. C. J. Mason in the Dec. 10, 1929, number said that this was doubtful, and advised shortening the low-pressure cutoff. I gave an example in the Jan. 14 number to show that increasing the high-pressure cutoff would do it; but said that it was not good practice.

Then D. P. Tolton adds to the discussion a combined diagram with which he shows that decreasing the low-pressure cutoff is the proper remedy. That is correct; but due to this being the only side of the question presented by him, it might be inferred that it is the only way possible.

On Mr. Tolton's diagrams, which appeared in the April 8 number, the high-pressure cutoff is about 20 per cent and the low-pressure 55 per cent. The desired diagram must show a high-pressure cutoff of 20 per cent, and, because of the cylinder ratio being approximately 3.8 to 1, a low-pressure cutoff of about 26 per cent. A larger diagram, caused by a later high-pressure cutoff, is not possible with the same load. The governor will not

permit it. Therefore, if the high-pressure cutoff is increased to 42 per cent, will not the governor, which controls the cutoff on both cylinders, decrease the low pressure cutoff to the desired 26 per cent and at the same time decrease the high-pressure cutoff to 20 per cent, making a perfect diagram? Reference to the accompanying theoretical diagrams would tend to prove it.

Say we have a condition that gives us diagrams as in Fig. 1. For a perfect diagram, we must bring the low-pressure cutoff back to coincide with the line that marks the end of the high-pressure displacement. Suppose we lengthen the high-pressure cutoff and leave the low-pressure cutoff alone, so that we have diagrams as shown in Fig. 2. An engine in this condition, with only its previous

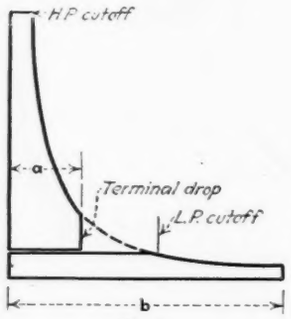


Fig. 1

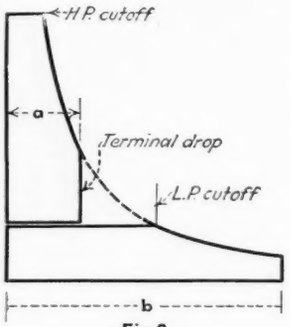


Fig. 2

a = H.P. displacement
b = L.P. "

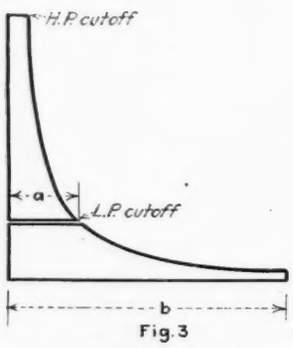


Fig. 3

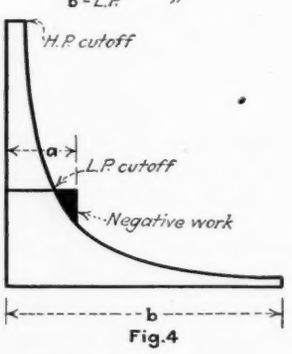


Fig. 4

Theoretical diagrams of compound engine

load, would attempt to speed up. The governor would then decrease the cutoff on both cylinders, until the high-pressure cutoff was the same as in Fig. 1. We then have the conditions shown in Fig. 3, a perfect diagram.

The drawback to this method is that the governor has a position away from its center of travel at normal load. This is not desirable, and it was for this reason that I said in my previous remarks that it was not good practice.

The theoretically ideal conditions for a cross-compound engine are such that the volume of steam in the low-pressure cylinder at cutoff is equal to the displacement of the high-pressure cylinder, and the governor is in its center of travel, at normal load.

The negative work done by having the low-pressure cutoff too early is shown by Fig. 4.

Middletown, Ohio. RAYMOND F. BENNETT.

✦

THE QUESTION of whether both cylinders of a compound engine should do the same amount of work; that is, develop exactly the same power, remains unsettled. Probably, in the first place, the designer intended equal powers for a specific total load on the engine, with given pressures, revolutions per minute, etc. But with any, or all, of these factors changed from those originally considered by the designer, it is necessary to change the distribution of power between the cylinders to meet a new set of conditions. The new conditions may tend to reduce the economy of the engine, but the physical and mechanical requirements must be met, irrespective of economy. These are things the operating or chief engineer must consider and pass judgment on.

Now there is another consideration than that of equal powers in the cylinders of cross-compound engines, and that is the desirability of having the initial loads on the piston rods, crossheads, connecting rods, cranks, etc., equal, in order that these parts may be duplicate, as they are, and yet be of equal strength. The initial load is independent of the cutoff; thus there is no relation between the initial load and the work done in the cylinder. It will be understood that the initial load is found by multiplying the area of the piston by the initial steam pressure. It is possible with an equal division of power in the cylinders to have the greatest stresses on the parts of the engine on one side in excess of the greatest stresses on the parts of the other side. So it would seem that the power should be so distributed in the cylinders that the initial loads will be equal or nearly so. What should it be? Equal powers or equal initial stresses on the parts?

Brooklyn, N. Y. CHARLES J. MASON.

Experiences With Boilers in Holland Over a Six-Year Period

ACCORDING to reports issued by the Governmental Steam Boiler Inspection Service of Holland, during the years of 1923 to 1929 the number of steam boilers is increasing slowly, as a result of the introduction of higher steam pressures, thereby paving the way to higher efficiencies.

High pressures and temperatures forced the boiler inspection staff to study construction materials closely. Again stress was laid upon the fact that Stevens-Martin boiler plate steel, after 40 years of boiler-making experience, was not reasonably reliable and unexpectedly gave way in many cases. Tension and bend tests of the defective material were not conclusive and fatigue phenomena were only brought to light by the hammer test. These phenomena then disappeared almost entirely after annealing the test pieces.

The steam drums of two water-tube boilers and the shells of four Lancashire boilers cracked during a hydrostatic test. The cracks in the water-tube boiler drum further contributed to the weakening effect of the large opening in the drums providing the connection with the waterlegs. It was recommended to drill a series of holes, instead of cutting the regular large opening. These steam drums were entirely renewed.

Cracking of two-flue boilers occurred, in each case, in the center of a course. Three of the boilers were only one year old. All of them were discarded after testing the material.

One steel mill is now producing a special boiler plate steel. This material was tested in the presence of boiler inspectors in the laboratory of a boiler manufacturer and proved superior to the ordinary steel plate. However, the new material was too expensive.

In a few instances over- and under-heated rivets were

found and were replaced. Riveting with too high a pressure proved to be again a dangerous practice, inasmuch as small cracks developed around the rivet holes which finally endangered the whole seam construction, so that in many cases flues had to be replaced.

It was considered questionable whether the regular brass boiler mountings would resist successfully pressures above 230 lb. and their corresponding temperatures. In the past this kind of material was always recommended on account of its resistance to corrosion.

An advantage of electric welding is that the surrounding material is heated only slightly, so that shrinking strains do not occur afterward. The welding temperature, however, is easily made too high, impairing the soundness of the weld. Anyway, the best results were obtained with electric welding. Almost any mechanic understands gas welding more or less, and that is in all probability the reason for the unsatisfactory results obtained.

Welding fire tubes to the tube sheet was considered practical, because too much rolling of the tubes deadens the material. Accidents on that score were not an exception.

The fusible plug was considered unreliable because it never acts properly, or only when the top part of the flue is getting red hot. Consequently, many cases of bulging are on record, in a few instances the bulge touching the grate. The safety whistle in connection with a fusible plug was again recommended.

An electrical device for indicating the water level of high water-tube boilers by means of lamps and contact-making plugs was approved.

The method of preventing scale by connecting the boiler to a low-tension circuit was disapproved, for fear of the liberation of corrosive oxy-genium. Of course, even the most systematic boiler supervision and inspection system cannot prevent all mistakes and accidents. One fireman opened the blowoff cock entirely and tried to remove an obstruction by means of a piece of wire after taking the blowoff piping apart. He was scalded to death.

A fire tube of a "locomobile" power plant leaked badly and it was decided to take the boiler out of operation. When the pressure was decreased to 30 lb. the chief engineer crawled into the flue to inspect the leaky tube. Then the tube failed entirely and the engineer was severely injured by the escaping steam and died a few days afterward.

In a bakery, a low-pressure boiler for 8 lb. pressure was used. The foreman adjusted the safety-valve spring for some reason or another, causing the boiler to explode, thereby killing a man. It turned out that the safety valve was set for a pressure of 225 pounds.

In another case the upper row of tubes of a water-tube boiler leaked, so that one of the bottom tubes was corroded by the drip, while the boiler was steaming. Finally, this tube let go, and one of the firemen was killed.

However, the majority of accidents were caused in connection with the operation of the Scotch marine type of boiler with its flat-stayed surfaces. Two boilers, apparently in good condition, exploded and caused four deaths. The other accidents were due to broken manhole covers, a flange unsatisfactorily brazed to the water-gage column piping, and weakened fire-tube material.

From Jan. 1, 1923, to Jan. 1, 1929, twelve men were killed. During that period, the number of high-pressure boilers was between 15,500 and 16,000.

One fatal case was caused by the explosion of an unfired pressure vessel in a chemical works. Cast iron was again condemned as a construction material for this type of container and a period of four years for consecutive internal inspections was deemed too long.

Many shortcomings of the human element as to the handling of water gages were recorded. One ship owner had to pay a big repair bill because his boiler was fired up while containing no water at all.

Epe, Holland. H. WIELAND LOS.

Taking the Kinks Out of An Induction Motor Starter

RECENT DISCUSSION in *Power* concerning starting of induction motors at full voltage brings to mind an interesting problem. A 75-hp., 440-volt, vertical induction motor connected to a deep-well pump was started by an automatic controller actuated by a float switch in an elevated tank. The starter was equipped with a two-coil compensator, connected open-delta, which was supposed to supply the motor with 60 per cent voltage for starting. The running, or full-voltage, fingers closed when a current relay opened as the starting current was reduced to a predetermined value. This relay consisted of several turns of heavy wire connected in series with the load. When it dropped open, as the current through it decreased, its auxiliary contacts closed the circuit to the running-contactor's closing coil.

Operation was never entirely satisfactory, for the control could never be adjusted to give a consistent and uniform time of starting the motor. Finally, it was impossible to prevent the two contactors from closing without any perceptible time between. Since the motor was not constructed for full-voltage starting, a drop of about 120 volts resulted on the 2,300-volt system, and could be noticed back to the power house over 32 miles of 60,000-volt line. This was so annoying that the engineers of the company which served the pump undertook to correct the trouble.

Two compensators were burned out before the matter was brought to the attention of the engineers. The fault was found to be too little iron in the core of the compensator, which was corrected by winding new coils, using the iron from both of the burned-out transformers.

To correct the relay trouble the old one was replaced by an induction type actuated by voltage. This relay was connected in series with a resistance and across one of the coils of the compensator. With sufficient resistance to limit the current in the relay to the capacity of its coils, it gives a definite time of closure dependent only on the voltage. It was set to close 7 sec. after the starting contact closed the circuit to the compensator. The motor was put in service, and for three years no trouble has been encountered with the compensator or the method of starting.

While the compensator was being wound the motor was started on the 220-volt taps of the power transformers, using the automatic starter with the new relay and a set of leads from the transformers to the pump house. The work was done by the writer under the direction of R. W. Shoemaker, then superintendent of the electrical department of the Turlock Irrigation District.

M. M. MCINTIRE,
Imperial, Calif. Imperial Irrigation District.

From Among Readers' Problems

Conducted by

L. H. MORRISON

BACK CONNECTION OF RETURN-TUBULAR SETTING—*What should be the distance from the rear end of a return-tubular boiler to the back wall of the setting?* C.A.S.

There should be a space 24 to 30 in. to give sufficient room for a man to enter the rear connection for inspection and cleaning and for expanding the tubes and renewing fusible plugs. When sufficient space is allowed for such purposes, ample passage will be afforded for conveying the furnace gases from the combustion chamber to the tubes.

ADVANTAGES OF OUTSIDE-PACKED PLUNGER PUMPS—*What is the advantage of outside-packed plunger pumps over piston pumps?* R.E.H.

Outside-packed plunger pumps are better adapted to pumping against high pressures than piston-packed pumps; it is indicated at a glance whether a plunger packing is tight, and the packing is more easily renewed than piston packing. The tightness of plungers is less affected by handling gritty water than the cylinders of piston pumps, and worn plungers are more easily repaired or replaced than worn water cylinders.

MOTOR GENERATORS FOR CHARGING STORAGE BATTERIES—*What size motor generator is required to charge a 60-cell storage battery that has an 8-hr. discharge rate of 25 amp.? The battery will be used to operate oil switches that require 125 amp. to close.* M.E.W.

The method of charging the battery will influence the size of the machine required to charge it. Also, in some cases the motor generator set is required to act as a substitute for the battery in case of emergency. In the latter the generator must have sufficient capacity to close the largest oil switch. This practice does not seem to be warranted, as it requires a motor-generator set of large capacity compared to the work that it will normally be required to do. A properly cared for storage battery is a most reliable source of power, and it is not usually necessary to provide stand-by capacity for it. If the generator is required to charge the battery at its normal 8-hr. discharge rate it should have a normal current capacity of 25 amp. This generator should also be capable of developing about 2.6 volts for each cell in the battery, or, in this case, about 160 volts, and 4-kw. capacity. The generator can be operated for about two hours at a rate 25 per cent higher than normal, if it is desired to charge the battery at this rate.

It is becoming general practice to charge batteries continuously, that is, give them a trickle charge. Under these conditions rate of charge is only about one-eighth of normal and size of charging equipment can be reduced accordingly. For this service the generator must be so designed that when a heavy load is applied to the battery most of it will be taken by the latter, otherwise the generator will be excessively overloaded. A shunt type machine is best suited to this service.

OBTAINING SAMPLE OF FLUE GAS ANALYSIS—*At what point of a boiler setting should samples of flue gas be taken for CO_2 determination?* J.F.

Samples of flue gas are usually taken from the breeching between the boiler and stack, and preferably where the gases are just leaving the boiler. The sampling tube should be made of a small size of pipe with a number of $\frac{1}{8}$-in. holes drilled in its sides, and extended nearly all the way across the breeching, so the sample of gas collected will represent the average of flue gases discharged to the stack.

PREVIOUS QUESTION

Discussed by Readers

THE QUESTION

SHOULD boiler make-up water be computed as the difference between the total water taken into the system and the known losses, which would include all blowdowns and water used to refill boilers? R. F. H.

IN COMPUTING boiler room records the amount of make-up water is secondary to the amount of water actually evaporated by the boilers. Since this latter is the true criterion of boiler room operation, it follows that special consideration should be given it to arrive at a correct figure. Make-up, as the name implies, is the amount of water necessary to make up the losses due to blowdowns, leaks, evaporation, and other causes.

In several public-utility plants with which I have been connected the amount of make-up is read directly from a meter in the raw-water line to an open heater. This is the total amount of water brought into the system. All of these plants operate with clear wells supplied from evaporators or condensate in excess of the demand at any time. In other words, the clear well acts as a reservoir to conserve condensate and as a supply to refill boilers after they are drained. Water level in the clear well is kept constant by a float-operated valve in the raw-water line. Consequently, the water used to refill a boiler is included in the make-up, but since when a boiler is drained the water is returned to the clear well, this is not an actual loss.

In filling a boiler, Venturi-meter readings are taken and deducted from the reading after the boiler is placed on the line, so that the boiler evaporation is figured only on the amount of water actually evaporated.

It is my opinion that boiler make-up should be the total amount of water actually brought into the system, including the known losses and blowdowns. Daily consideration of the per cent of make-up will then indicate excessive blowdowns or other losses, while the true performance of the plant will be given by computing only the amount of water actually evaporated by the boilers in service. S. E. TRAY.

Jackson, Mich.

IF IT were only desired to know the amount of make-up water added to the system, it would be a simple matter to meter the cold make-up water. But that information alone is of little

value in determining the proportion of losses to total evaporation.

To obtain a comprehensive record, all steam generated should be metered, and the total for the period considered compared with the feed water meter readings. The difference between the steam-flow meter and the feed-water meter readings would account for all water used for filling boilers, blowdown water, steam lost through the pop valves, moisture content of the steam, and all water and steam leaks on the boiler side of either meter.

If the plant is run condensing, or, in the case of a heating or industrial plant, if the steam is all condensed and returned to the system, the make-up water meter readings should be close to the difference between the steam-flow and the feed-water meter readings. If the steam is not condensed and returned to the system, the loss will be indicated by an increase in the make-up water meter reading. Comparison of the three readings should give some useful data.

If a plant produced 160,000 lb. of steam, and feed-water meter readings were 168,000 lb., and the make-up water meter showed 20,000 lb., then 168,000 — 160,000 = 8,000 lb. of water lost to the plant in blowdown, moisture in the steam (see page 679 in April 29 issue of *Power* for method of correcting flow meter readings for moisture), leaks, etc. So 20,000 — 8,000 = 12,000, the loss of condensate, and $\frac{20,000}{160,000} = .125$ or $12\frac{1}{2}$ per cent of make-up water used.

A record of these items is useful in noting losses such as leaking blowoff valve and breaks in the condensate return lines from remote parts of the system, which ordinarily might go undiscovered for some time. In one case, a leak in a steam coil in a water heater, which permitted water from the heater to enter the condensate return, was first noted by the failure of the make-up meter to show the usual amount of consumption.

A. C. McHUGH,
State Hospital.
Norwalk, Calif.

FAILURE to include the blowoff and refill water would not give a true measure, as this water has to be bought (or pumped); otherwise the only make-up water charged would be that required to replace that lost by gage cocks, safety valve trials, non-condensing engines and pumps, and miscellaneous leaks, whether from radiators, defects in piping, etc., or any other of the ways in which it may get away. A steam-atomizing oil burner will use 4 per cent of the total water evaporated; and soot blowers consume their share. Furthermore, anyone who has operated a boiler over banked fires for a length of time must have noticed that the water level falls slowly even though there are no visible leaks.

My method would be to operate a water softener of the lime-soda or lime-barium-alum type, which handles the water in batches, and attach a revolution counter to the float, after gaging carefully the average amount handled at each batch. From the total used in any given time should be subtracted any water (either condensed or steam) used for drinking, cooking, or fed to non-condensing engines or pumps. Steam consumed by an oil burner or steam jet should be charged, also blowoff and refill water. With a lime-barium softener, the blowoff water can be returned to the softener, unless taken from the ocean or the vicinity of salt springs. With a sodium reagent, whether a lime-soda or zeolite softener, it must necessarily be rejected. In either case, the blowing down and refilling need not be so frequent as it would have to be with untreated water or that where softeners are fed with the water.

At one time I hit on the brilliant idea of feeding barium hydrate to filtered water for boiler feed. When we opened the boiler the sludge washed out readily with a hose, but the inside of the tubes and water drums were coated to the depth of a sixteenth of an inch with a white enamel which defied all efforts, chemical or mechanical, to remove it. Since then I have added the precipitants before filtering. But I can recommend it to anyone troubled with corrosion, as neither concentrated muriatic or sulphuric acids had any effect on it.

Cleveland, Ohio. L. R. BAKER.

A Question for Our Readers

THE three collector rings of a three-phase, wound-rotor 200-hp. 440-volt motor are short-circuited by a drum switch. With extremely poor contact at one of collector rings how will the stator current be affected at full load? What percentage of normal current will flow in the leads connected to the brushes that are making good contact, assuming that only two leads are carrying current? If this motor is operated in this way is the rotor winding likely to be damaged? How much will the motor's capacity be reduced if only two slip-ring brushes make good contact? R. L. H.

Suitable answers from readers will be paid for and published in the July 1 number.

IF THE make-up water lines are installed in the proper manner and metered correctly, one of their most beneficial purposes is to serve as a check on the boiler make-up. If there should be any unusual steam losses, it would be very noticeable from the amount of make-up water added to the system.

In one instance I recall there was a steam line taken off of the header in front of the meter, the line being metered at the point of consumption. The steam system was a large one and the department using this particular steam line was shut down. Someone forgot to turn the steam off, and it kept on blowing through the lines to a steam well until it was accidentally discovered some days later.

As a remedy for this condition, and to prevent recurrence, I should suggest that a separate meter be installed on the make-up line to the condensate or storage tank. This meter could be located on the exit or discharge side of the water softener, if it is a pressure softener. Readings taken from this meter daily would show the make-up water supplied to the boilers and would give a good idea as to the amount of water lost as sealing water for the turbines and pumps, evaporation, steam leaks, water leaks, etc. The condenser cooling water might also be included in the make-up.

It would hardly be accurate to report all water brought into the system and let this serve as a comparison between plants, as the amount of water lost through the boiler blowdown varies widely. I know of one plant where the water contains a large percentage of alkali. To prevent possible caustic embrittlement of the boiler metal, enough sodium sulphate is used to keep the ratio about 3 to 1, and it is necessary to blow the boilers twice a day to prevent concentration, large quantities of water being lost in this manner. Other plants that one might wish to compare with this one would probably blow the boilers once a day. However, the meter on the make-up water would serve as a daily check for the one plant.

Let the make-up water be a check on the system—not a result.

RALPH RAINEY.
Albuquerque, N. M.

BOILER make-up water is total boiler feed minus condensate returns. That is probably the simplest way to answer this question. The amount of blowdown should not enter into the discussion. All water made up fresh to the heater is make-up water. This may come from evaporators, softeners, or direct from a raw-water line. For example a boiler evaporating 1,000 lb. of water an hour, blowing down 100 lb. an hour and returning from turbines as condensate 500 lb. an hour would require a make-up of 600 lb. an hour.

With a closed heater it is possible for a plant to have 100 per cent make-up, but with an open heater this is an impossibility, because a part of the boiler feed comes from steam, either live or exhaust, which is condensation and therefore not make-up.

H. A. GUSTIN,
National Aluminate Corp.
Chicago, Ill.

THE ENGINEER'S B

Steam Power Economics

STEAM GENERATION STEPS AHEAD. *By G. B. Gould. Published by the Fuel Engineering Company, 116 East 18th St., New York City; 1930. Cloth; 5 x 7½ in.; 102 pages. Price, $1.*

CONCISE, yet inclusive, well-written, readable and fundamentally practical, this little book is ideally suited to the needs of industrial executives who find it necessary or worth while to acquire some general knowledge of steam generating problems from the business angle.

Mr. Gould deals, in the main, with the fuel problem, particularly the selection of a grade of fuel that will insure dependable operation at the lowest over-all cost. The broad general principles laid down include many highly important factors often overlooked in overemphasis on the simple B.t.u. cost of various fuels.

This book is directed particularly to executives of industrial plants in the range from 500 to 5,000 hp., a class very important in its aggregate purchases of fuel. As the author points out in the introduction, there is danger that such plants may attempt to apply without modification methods that have proved successful in superstations.

❖

More on Public Ownership

FORCES AFFECTING MUNICIPALLY OWNED ELECTRIC PLANTS IN WISCONSIN. *By E. Orth Malott. Published by the Institute for Research in Land Economics and Public Utilities, 337 East Chicago Ave., Chicago, Ill.; 1930. Paper; 7½ x 10 in.; 101 pages, charts and tables. Price, $1.50.*

FOLLOWING closely on the heels of Dr. Herbert B. Dorau's "The Changing Character and Extent of Municipal Ownership in the Electric Light and Power Industry," a review of which was published in *Power* of March 4, the second monograph in the series on municipal ownership carries the investigation forward with a detailed analysis of conditions in Wisconsin. This state was chosen as promising a fair sample of municipal ownership, says Dr. Malott, because it was one of the first to establish comprehensive laws for the regulation of power plants and because its utilities are still in a state of flux due to the fact that economic forces within the state have not as yet reached equilibrium.

In this study Dr. Malott considers legal, technical, and financial factors affecting municipal electric plants. While laws governing these plants in Wisconsin are gradually being liberalized, he finds that many legal restrictions have stood in the way of their formation and progress, particularly the law limiting municipal debt to 5 per cent of the taxable property. Similar handicaps are found in the technological factors and the inability to obtain efficient management, though Dr. Malott believes these apply to all small plants, whether privately or publicly owned. He concludes that "the financial handicap, and the technological handicap, which are created by legal restrictions, and the managerial handicap, which, in turn, is created by the public itself, are the main factors influencing the municipal ownership movement in Wisconsin, whether considered from the point of view of progress, of efficiency, of rates, or of the changing character of ownership."

The same care and precision in the compilation of statistics and the presentation of unbiased facts pervades this study that was apparent in the first in the series.

❖

Soviet Development

SOVIET ECONOMIC DEVELOPMENT AND AMERICAN BUSINESS. *By Paul G. Bron. Published by Horace Liveright, 61 West 48th St., New York, N. Y., 1930. Cloth, 8 x 5 in.; 147 pages, tables, diagrams and appendices. Price, $1.50.*

HOW the results of the first year of operations under Russia's Five-Year Plan exceed expectations is revealed in this detailed report of that year, by the former chairman of the Board of Directors of the Amtorg Trading Corporation. It is the first authentic account published in this country of the considerable upward revisions in the Five-Year Plan, with a detailed analysis of the prospects for 1930 and coming years. Mr. Bron has made available hitherto unpublished material regarding the scope of the economic relations between the United States and the Soviet Union. He also touches on present obstacles to Soviet-American trade.

The author indicates that the growth of the tractor, automobile, oil, power plant, chemical and other industries in the Soviet Union, now undergoing intensive development, may have considerable bearing on the future course of Soviet-American trade, and should be of great interest to American industrialists.

Industrialization of the U.S.R.R. and reorganization of agriculture along new lines have made Soviet Russia one of the most important markets for American machinery and equipment. Soviet-American trade in 1929 reached a total of $155,000,000, an increase of 50 per cent over the preceding year. A detailed account of what this business consisted of, with complete tables of Soviet purchases and sales in America, is given, together with an enumeration of openings for foreign concessions in the Soviet Union, and a list of the large industrial enterprises under construction.

Piping Reference

PIPING HANDBOOK. *By J. H. Walker and Sabin Crocker. Published by the McGraw-Hill Book Company, Inc., 370 Seventh Ave., New York City., 1930. Flexible cloth; 4¾ x 7¼ in.; 763 pages, charts and tables. Price, $5.*

BOTH designing and operating engineers have long felt the need of a thorough reference book on piping—such as has now been made available. Not only does it cover the basic fundamentals of piping system design, but, also deals with the piping problems peculiar to steam power plants, building heating systems, plumbing, underground steam piping, water supply, fire protection, oil, and gas.

More than one-fourth of the book is devoted to the properties of fluids and fluid flow through piping systems, nozzles and orifices. Charts for finding pipe friction losses based on some of the most recent experimental data are presented.

A chapter devoted to metallurgy of piping materials discusses materials to be used to meet various conditions. In particular, information is given regarding the behavior of metal at elevated temperatures, together with tables containing useful physical data of various alloys and materials.

Under the heading of Pipe, Valves and Fittings are gathered tables of standard dimensions for all the various classes of pipe and pipe fittings. In addition, screened, welded, and flanged joints are discussed. An analysis of the stress in flanges is given, together with data on flange belting. Considerable space is devoted to pipe expansion flexibility, and support.

❖

The World of Matter

FOUNDATIONS OF THE UNIVERSE. *By M. Luckiesh. Published by D. Van Nostrand Company, 250 Fourth Ave., New York City. Cloth; 6 x 8½ in.; 245 pages; illustrated. Price, $3.*

MAN, as the author of this book points out, stands midway between inconceivably great and small distances. In an entirely popular treatment of physical science the reader is taken on a journey into these spaces. Scientists have been able to reach out into space thousands of light-years and learn much about the worlds that exist in those far-distant stellar regions. Out there are worlds so large that the earth is but a speck in comparison. When man produces and maintains temperatures of a few thousand degrees he has reached his limit, yet in some of the far-off stellar

BOOKSHELF

crucibles temperatures of 40,000 deg. F. are developed.

Turning to the infinitely small, we are taken inside a particle of matter so minute that it must be a thousand times larger to be visible under the most powerful microscope made. Inside the atom, the smallest division of matter, we find a system not unlike the solar system. In the center is a positive charge of electricity with negative charges rotating about it. That is, when matter is traced down to its almost infinitesimal constituents it is found apparently not to exist at all as the realistic matter we have supposed it to be. However, throughout the inconceivable range from stars to atoms the same physical laws seem to reign.

A systematic and popular picture of the foundations of the universe is presented, as it now appears. Some of the chapter headings are Matter and Motion; The Realm of the Molecules; What Is In Space; The Epoch of Einstein; The Electron Theory; Inside the Atom; The Fateful Unknown. These give an idea of the treatment.

Although great progress has been made in our understanding of the fundamentals of nature one may well ask the question that the author has asked, will we ever reach the beginning of things? To those who wish to speculate there is no limit to which the imagination may wander in these realms. For those who care to remain with the known facts about the universe as presented, the reader will find many of them more astounding than fiction.

❖

Germany's Power System

REICHSELECTRIZITÄTS-VERSORGUNG. *By Oscar von Miller. Published by VDI-Verlag GMBH, Dorotheenstrasse 40, Berlin N. W. 7, Germany. Cloth; 8½ x 11¾ in.; 27 pages, 42 tables, 23 colored plans and diagrams.*

THERE is no need to stress the fundamental nature of this report on electricity supply for Germany. The name of the author is sufficient to give the data their full weight. A foreword by Dr. A. Julius Curtius, Secretary of Industry of the Reich, explains the purpose of this report. It is not a government plan of future expansion, but the government initiative to collect the fullest statistics and trends into a comprehensive whole in order that these may serve to co-ordinate the efforts of private enterprises and local governments. Since the last sitting of the State Electrical Council, in 1926, the movement of co-ordination made a step ahead, by the formation of Aktiengesellschaft für deutsche Electrizitätswirtschaft, which will combine the planning work of major electrical concerns into a unified rational program of expansion along the lines indicated in the report.

The report itself is divided into two parts: the technical aspects and the economics. Both parts contain complete statistics and information on German conditions, and, of course, are valuable as a guide for other countries. The ultimate interconnected system of energy distribution in Germany as shown on the plans is the practical ideal suggested by the state for common utility, and its attainment shall require a great deal of co-operative spirit among the different interests and concerns called to realize it.

N. C. ARTSAY.

Wiring Handbook

STANDARD WIRING FOR ELECTRIC LIGHT AND POWER. *By H. C. Cushing, Jr. Published by H. C. Cushing, Jr., 341 Madison Ave., New York City, 1930. Flexible binding; 4 x 6½ in.; illustrated, 512 pages. Price, $3.*

FEW BOOKS can boast of a 36 edition as this one can. Each year a new edition is published to give the latest practice adopted by the national electrical code. The text covers standard wiring for electric light and power as adopted by the 1930 fire underwriters of the United States. Included are explanations, illustrations and tables for inside and outside systems of wiring.

A new section has been added on the National Red Seal Plan for adequate house wiring. The Franklin specification is included, for the lighting of commercial, industrial and public building interiors, and other buildings. The book contains many tables and other information essential to doing electric wiring work, and the material is presented in a form that makes it readily usable by the practical man.

●

Brief Reviews

STANDARDS YEARBOOK 1930. Compiled by the National Bureau of Standards; miscellaneous publication No. 106; 301 pages, cloth; for sale by the Superintendent of Documents, Government Printing Office, Washington, D. C.; price 75 cents.—This is the fourth edition of an annual that has proved indispensable to all interested in any phase of standardization in America and abroad. It is a reference book, summarizing and bringing up to date current standardization activities.

WÄRMEWIRTSCHAFT IM KESSELHAUS. By Ernst Praetorius. Published by Verlag von Theodor Steinkopff, Dresden, Germany.—Much of interest to the power plant engineer will be found in this book, particularly with respect to heat losses occurring in different parts of the boiler plant, to modern automatic grate design, boilers, the various types of pulverized-coal burners, superheater and economizer design and practice.

OXWELDED CONSTRUCTION FOR MODERN PIPING SERVICES. Published by the Linde Air Products Company, 30 East 42d St., New York City. Paper, 77 pages, illustrated; free.—Of interest to all contemplating the installation of steel or wrought-iron piping, this book presents the pertinent facts concerning advantages of the oxy-acetylene process for the fabrication of such piping systems for all purposes.

FOREIGN COMMERCE HANDBOOK 1930-1931. Compiled by the Foreign Commerce Department of the United States Chamber of Commerce, Washington, D. C. Paper, 44 pages; free.—Containing the latest information on foreign trade practices, this is a valuable reference book for all engaged in exporting.

LIGHTNING INVESTIGATIONS, DISCOVERIES AND CONTROL. Bulletin C.1737-E of the Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa. Paper, 20 pages, illustrated; free.—An interesting description of the latest discoveries in the effect of lightning surges on electrical systems.

ELECTRIC STEAM GENERATORS. No. P-3 in the Marketing Electric Series published by the Commercial National Section of the National Electric Light Association, 420 Lexington Ave., New York City. Paper, 23 pages, illustrated; price, 60 cents.—This report contains information on the applications and installations of electric steam generators and the methods employed to promote their use.

SCIENTIFIC RESEARCH SOLVES THE BOILER WATER CONDITIONING PROBLEM. By R. E. Hall. Published by the Hagan Corporation, Pittsburgh, Pa. Paper, 30 pages; free.—Dr. Hall, formerly of the United States Bureau of Mines, explains the discovery and development of the new, molecularly dehydrated, boiler-water-conditioning chemical for the prevention of scale, corrosion and foaming in steam boilers.

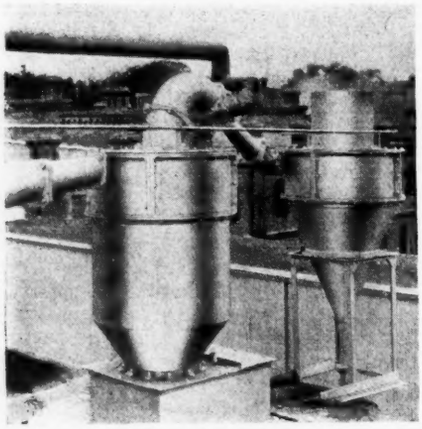
WHAT'S NEW IN PLANT EQUIPMENT

HOW THE MANUFACTURER CONTRIBUTES TO THE JOB OF GENERATING, TRANSMITTING AND APPLYING THE POWER SERVICES

Pneumatic Ash Conveying System

IN THE field of pneumatic conveying for the handling of ash, soot, and other abrasive materials, a comparatively new development, designated the "Nuveyor," has been introduced by the United Conveyor Corporation, 507 Old Colony Building, Chicago, Ill., to eliminate certain disadvantages of the pipe-line conveyor while retaining its simplicity, flexibility, and ease of installation. Basic features characterizing its operation may be summarized as follows: No steam comes in contact with the ashes, and, as the ashes are delivered dry to the storage tank, they will not freeze or pack, and will discharge freely by gravity. High capacity and low steam consumption is obtained by the use of a Venturi tube, multi-steam jet exhauster. A special receiver does away with the need for an airtight storage tank. A washer and silencer eliminate dust and noise.

The "Nuveyor" consists, essentially, of four units, as follows: The conveyor pipe line, a receiver that collects and automatically discharges the conveyed material to the storage tank, a multi-steam-jet exhauster (which, if desired, may be replaced by a centrifugal fan or a rotary positive blower), and a combination washer and silencer. The accompanying sectional view illustrates the arrangement of the system and the principles of operation. The photograph shows a typical installation.

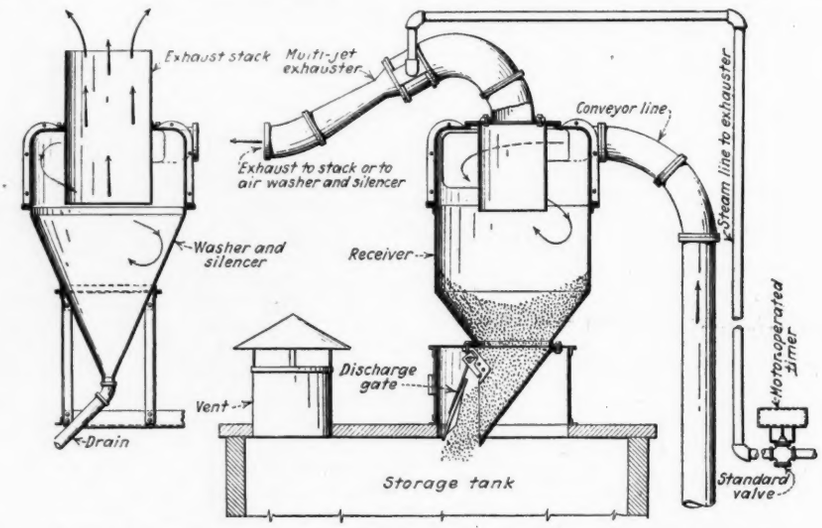


Typical installation of "Nuveyor"

With branches as required to ash pits, combustion chambers, breeching, and stack, the conveyor pipe leads from these points of accumulation to the receiver on top of the ash storage tank. To start the system, the operator pushes one of the switch buttons located near each ash intake. This starts the timer motor, which opens and closes the steam valve to the multi-jet exhauster and by directing the jets through a combining tube of Venturi design draws a large volume of air out of the receiver. The inrush of air through the receiver discharge gate, which hangs open when the equipment is not in operation, swings the gate to the closed position, and the partial vacuum created in the receiver holds it closed.

A high-velocity current of air is then drawn through the conveyor line, carrying with it to the receiver ash fed in at the intakes. Air and ash enter the receiver tangentially, creating a cylonic action that separates the ash from the air, the former settling in the bottom of the receiver, while the latter is drawn out from the top and through the exhauster.

Steam remains on for about 80 sec., whereupon the motor automatically closes the steam valve and holds it closed for about 5 sec. This shuts off the exhauster and breaks the receiver vacuum, which allows the discharge gate of the receiver to swing open by gravity and dump the ashes. This cycle is repeated automatically until the operator again pushes the remote control switch to stop operation. Operating and dumping intervals can be altered to meet any conditions.



Section through "Nuveyor," showing general arrangement of ash receiver, washer, and silencer

Air and steam from the exhauster are discharged to an air washer and a silencer. Entering at a tangent, the air and steam are given a whirling motion, causing them to impinge on a film of water sprayed from within the casing on to the outer walls. Centrifugal action carries the dust outside, where it comes in contact with the film of water and is carried away through a 3-in. drain pipe leading from the bottom of the receptacle. The air and any vapor that is not condensed pass out of the exhaust stack rising from the center of the washer.

The sharp change in direction of travel tends to throw down into the washer any dust or water carried in suspension. If desired, the air washer may be replaced by an exhaust pipe line venting to a stack or breeching.

In a cold climate the use of water in an out-of-door installation may be open to question. Possibility of freezing, however, is obviated by a special valve for the water supply that opens automatically when steam is turned on and closes automatically when steam is turned off. With this arrangement water is used only when steam is passed through the washer, so that it is maintained at a high temperature, and a valve provides for draining the water line after the conveying operation is over. An alternate method is to locate the air washer and exhauster inside of a building.

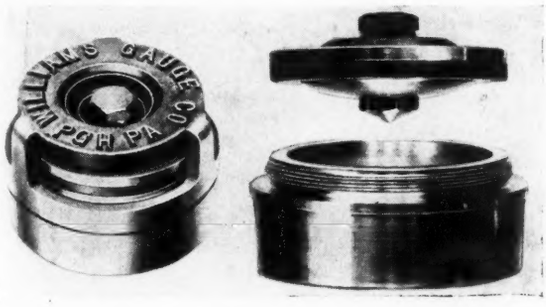
Depending upon the size of pipe line used, the "Nuveyor" may be had for capacities ranging from 5 to 30 tons per hour.

Floating Pump Valve

IN THE Williams pump valve here shown the essential improvement is the lowering of the cage. The legs used to guide the disk have been shortened and the top of the cage has been enlarged to an annular ring of the full valve diameter. The ring is recessed to seat an inverted beehive Monel metal spring that holds the valve disk to its seat.

As the illustrations show, the pump valve consists of four main parts: cage, spring, valve seat, and valve disk. Construction is practically indentical with that of the noiseless check valve made by the same manufacturer, the Williams Gauge Company, 343 South Dearborn St., Chicago, Ill., and described in the Dec. 17, 1929, number. Application of these floating check valves to the ports of a pump has eliminated frictional wear, removed usual obstructions to flow, such as ribs and webs, and has reduced slippage to a minimum.

These valves are suitable for boiler-feed, vacuum, wash-out, house-supply, and fuel-oil pumps. It is the manufacturer's claim that they are made for any service and for any pressure or temperature, and valves are now in service on units pumping crude oil at 750 lb. pressure.

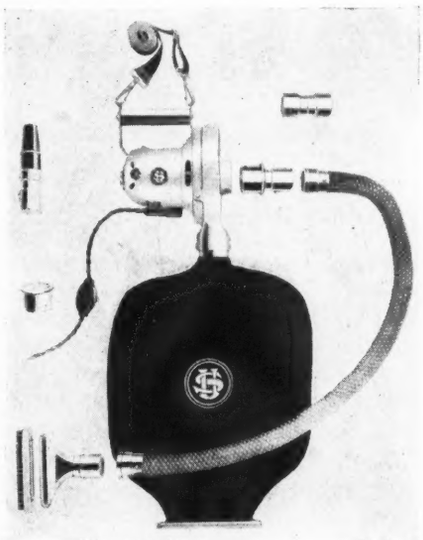


Pump valve assembled and view of disk and seat

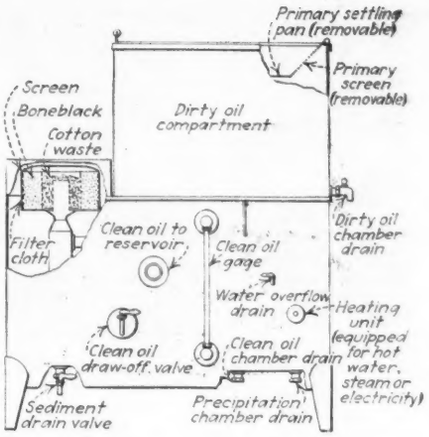
Combination Portable Blower and Vacuum Cleaner

A COMBINED portable vacuum cleaner and blower suitable for cleaning motors, instruments, and various other apparatus is illustrated. The change from a vacuum cleaner to blower is made by removing the dust bag and relocating the hose.

Made in two sizes, No. 1, with a weight of 7½ lb., and No. 2, with a weight of 9½ lb., the machine is arranged with an adjustable strap for slinging over the operator's shoulder or hanging on a hook. It is equipped with a universal motor and a quick-make-and-break switch. The combination unit is put out by the United States Electrical Tool Company, Cincinnati, Ohio.



Combination unit with attachments



Burt improved oil filter

Improved Oil Filter

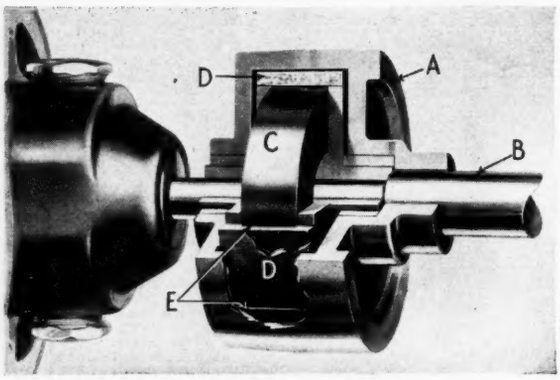
ALTHOUGH designed primarily for the reclaiming of crankcase oil, the fuel-oil filter illustrated is especially applicable to the purifying of any kind of oil. Although compact, occupying only 4 sq.ft. of floor space, it is said to have an unusually high holding capacity of dirty and clean oil.

It embodies the use of four distinct settling chambers, and the ultimate purification is through perforated screens, filter cloths, bone black, and white waste. In passing through the filter the oil does not come in contact with the filtering medium until practically 75 per cent of the impurities have been removed.

Provision is made in the design of the dirty oil compartment and precipitation chamber for the installation, when desired, of steam, hot water, or electric heating elements. The filter is a recent product of the Burt Manufacturing Company, Akron, Ohio.

Combined Coupling and Clutch Automatically Reduces Starting Loads

POWER required to start a machine from rest frequently necessitates a larger motor for driving than is actually necessary to operate the machine under full load or at maximum capacity. To permit of using a motor of the correct size for normal operation of a machine regardless of starting torque required, the Lombard automatic starter illustrated has been introduced by the Washburn Shops of the Worcester Polytechnic Institute, Worcester, Mass. Essentially a combination of a clutch and flexible coupling, the



Lombard automatic starter designed to give smooth pick-up without shocks or grabbing

starter consists of an outer housing *A*, keyed to the driven shaft *B;* an expanding centrifugal accelerator *C* keyed to the motor shaft; frictional linings *D;* and equalizing separators *E*. The expanding accelerator *C* contains a fluid (usually mercury for the smaller sizes and water for the larger sizes) which, when the accelerator is revolved, automatically gives the necessary pressure on housing *A* to transmit power to the driven shaft. In starting, the liquid is in the lower part of the accelerator, and there is an interval of time before it becomes distributed uniformly around the accelerator. Until this distribution takes place there is no effective pressure. This interval of time is sufficient to permit of the motor's reaching practically full speed before any appreciable load is applied. Gradual building up of the pressure exerted by the liquid is said to give a smooth pick-up without shocks or grabbing.

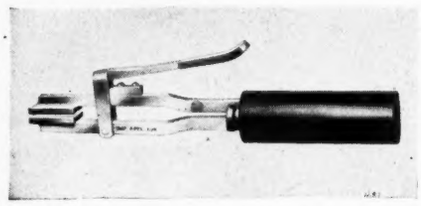
As will be apparent from the illustration, the accelerator *C* is completely inclosed within a metal housing. It is protected from wear by the frictional linings *D,* which are divided into a number of parts by equalizing separators, as at *E*.

Although the starter was primarily designed for use with motors, it may be applied to other types of driving units. It may also be applied to the driven unit, and can be arranged for direct connection (as illustrated), gear, chain, V-belt, or flat-belt drives. It will operate equally well in either a vertical or horizontal position or in either direction of rotation.

Metallic Electrode Holder

TWO SIZES of the Wachs metallic electrode holder illustrated are available. One is for electrodes from $\frac{1}{16}$ to $\frac{1}{4}$ in. in diameter, with current-carrying capacity up to 400 amp., and the other is for electrodes from $\frac{1}{4}$ to $\frac{1}{2}$ in., inclusive, with capacities from 400 to 800 amp.

A simple compression lever makes the grip on the electrode in place of the usual spring. The lever has a protective covering and is locked in place by a roller operating against a fixed rachet. The gripping surfaces are smooth and free from corrugations. The electrode can be held at any desired angle. The new holder is put out by the Northwestern Manufacturing Company, Milwaukee, Wis.



Electrode holder with ventilated handle

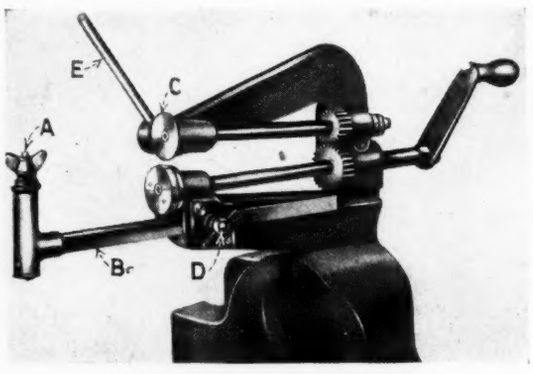
Gasket Cutting Machine

DESIGNED to cut gaskets in sizes from 2 in. up, quickly and with minimum of waste, the gasket cutter illustrated, put out by the Allen Gasket Cutting Machine Company, 6 Hazard St., New Bedford, Mass., is adaptable to gaskets of irregular shape as well as to ring gaskets.

In cutting standard ring gaskets a piece of sheet packing larger than the outside diameter desired on the gasket is punched in the center and clamped in position over center *A*. Then bar *B* is adjusted until the measurement indicating the desired diameter is even with the cutter *C*. The bar is then locked in position by a screw *D*. Lever *E* is moved until the cutter *C* pierces the sheet, then the crank is turned clockwise and the outside of the gasket is cut off. The operation is repeated on the inside cut.

For irregular-shaped gaskets, the outline is first marked on the sheet. Then the bar *B* is removed and the cutter used as shears.

Provision is made in the design for taking up any lost motion in the cutter shaft and for maintaining proper clearance between cutters.



Machine cuts ring- and irregular-shaped gaskets

Welding Electrode for Stainless Steels

LINCOLN Electric Company, Cleveland, Ohio, has recently introduced a new electrode, designated Stainweld A, to be used for welding stainless steel. Some of the advantages claimed by the manufacturer of the rod are that by its use welds made can be of the same chemical content as the stainless steel itself, resulting in a dense, ductile weld. This is accomplished by having the welding done in a protected atmosphere, thus excluding the oxygen and eliminating oxidation of the weld metal.

The rod itself is of the same chemical composition as the metal and is coated with a material which in the heat of welding forms a gaseous envelope around the arc. It is used with reversed polarity and permits of making a weld that is said to be as impervious to corrosion as the metal it joins. It is obtainable in three sizes, $\frac{1}{8}$, $\frac{5}{32}$, and $\frac{3}{16}$ in., of standard 14-in. lengths, and can be used for horizontal, vertical, or overhead welding.

NEWS of the FIELD

Spot News

•

BY A VOTE *of 196 to 114 the House of Representatives on May 28 passed the Reece bill providing for private operation of Muscle Shoals. Under the terms of the measure, which now goes to conference with the Senate, the President would appoint a leasing board of three members to negotiate a lease covering the Shoals plant with a private concern.*

•

IMMEDIATE CONSTRUCTION *of a $40,000,000 natural gas pipe line, 1,250 miles long, running from the Panhandle field in Texas to Indiana was announced May 27 by the Missouri-Kansas Pipe Line Company. This will be the largest super-gas system in the country, bringing natural gas to industrial centers in Kansas, Missouri, Illinois, Indiana, and Kentucky.*

•

WITH THE ELECTION *May 27 of Floyd L. Carlisle, chairman of the Niagara Hudson Power Corporation, to the board of the New York Edison Company, another step is seen in the inter-connection of these two great power systems. On the same day a new 30,000-hp. hydro-electric plant was dedicated at Conklingville, which will be one of the feeders to the new 132,000-volt transmission line tying in New York City with upstate hydro-electric plants.*

•

INAUGURATING *a new monthly compilation to supplement the reports on steel boilers and mechanical stokers, the Department of Commerce reports that new orders for pulverized-fuel equipment in April aggregated 43 mills with a total capacity of 146 tons of coal per hour, compared with 44 mills with a capacity of 97 tons per hour in March.*

•

A COMPREHENSIVE STUDY *of cracks in dams is to be undertaken soon by the Bureau of Reclamation under the direction of Professor H. W. Westergard, who has been engaged for several months past in special mathematical studies in connection with Boulder dam.*

Boiler Manufacturers' Association Holds 42d Annual Convention

Aldrich stresses importance of cooperation with Federal Trade Commission — Clemens elected president — Full-time organization recommended.

CO-OPERATION with the Federal Trade Commission and consolidation of activities under a full-time organization were recommended to members of the American Boiler Manufacturers' Association at their 42nd annual convention. Attended by a representative group of executives, the meeting held at Sky Top Lodge, Cresco, N. J., from May 26 to 28, featured a well-rounded program of business sessions and entertainment.

In his presidential address, which opened the convention on Monday, May 26, H. E. Aldrich referred to the success of the association in promoting the establishment of "such standards for materials and workmanship as will insure uniform excellence of construction of all American boilers, and thus secure safety to the lives and property of all communities where boilers are used, and to procure the passage of laws pertaining thereto." This he said is being accomplished largely through the adoption of the A.S.M.E. Boiler Code as a standard of manufacture, with the support of the American Uniform Boiler Law Society and the National Board of Boiler and Pressure Vessel Inspectors.

REFERRING to recent trade association executive meetings held in Washington in connection with the annual meeting of the United States Chamber of Commerce, Mr. Aldrich said it was agreed there by both the executives and the Department of Justice that the Federal Trade Commission is rendering an important service to industry. He urged the adoption by groups of codes of practice approved by the commission as a move of great value to the boiler industry.

Following President Aldrich's address announcement was made of the retirement of E. R. Fish from the boiler manufacturing field to accept a position as chief engineer of the Hartford Steam Boiler Inspection and Insurance Company. Of his election as honorary member of the A.B.M.A., Past-president William C. Connelly said Mr. Fish had been associated with the boiler industry longer than any other of the active members, and was associated with Colonel Meier in the founding of the association.

Mr. Fish as chairman of the A.S.M.E. Boiler Code Conference Committee urged more complete individual interest on the part of the members in the Code committee's work. He referred to the proposed procedure specifications for welding. A lengthy discussion regarding code committee relations and activities ensued. It was announced that the 1930 Code would probably be issued in November.

A LIST of instructions to inspectors proposed by J. P. Morrison of the Hartford Steam Boiler Inspection and Insurance Company, occasioned considerable discussion until it developed that they were submitted not for adoption or endorsement but for suggestion and comment; and they were intended for the guidance of their own staff and not as an additional code.

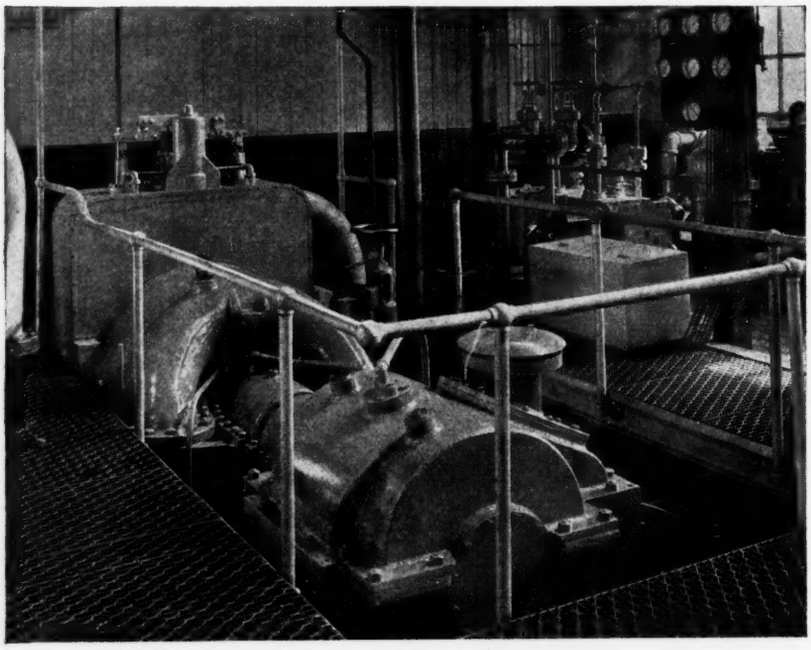
E. R. Fish presented a report on boiler suspensions, which recommended certain material and stress values to be used in the design and construction of structures for supporting boilers.

At the session on Tuesday a recommendation was made to merge the water-tube and horizontal-return-tubular division of the association with the power group. It was further recommended that steps be taken to call a meeting of all manufacturers of power boilers at Washington, D. C., on Sept. 17 to consider the formation of a full-time organization with a paid secretary to work along the lines followed by the heating boiler group.

Officers elected for the coming year are: President—H. H. Clemens, Erie City Iron Works; vice-president—Owsley Brown, Springfield Boiler Company; secretary-treasurer—A. C. Baker, Cleveland, Ohio; executive committtee—Homer Addams, Fitzgibbons Boiler Company; George W. Bach, Union Iron Works; F. W. Chipman, International Engineering Works; Sidney Bradford, Edge Motor Iron Company; E. G. Wein, E. Keeler Company; J. T. Dillon, Titusville Iron Works Company; C. E. Tudor, Tudor Boiler Manufacturing Company; A. C. Weigel, Hedges-Walsh-Weidner Company; and H. E. Aldrich, Wickes Boiler Company.

Entertainment features of the program included a golf tournament, the annual banquet, and a ladies' bridge tournament.

FIRST ALL-WELDED STEEL GEAR CASE



A 1,400-hp. geared turbine drive in which the first all-welded steel gear case was used has just been installed on the American Dredging Company's dredge New Jersey by the Westinghouse Electric & Manufacturing Company. Because the all-welded construction provides a lighter and stronger gear case, it has become standard practice for dredge installations

▼ ▼ ▼

Hearings on Boulder Dam Appropriation End

Whether Boulder Dam construction will start this season now rests with the House Committee on Appropriations, hearings having ended May 23. From all that can be gathered concerning what took place in the closed sessions, it is believed that the Interior Department has made its case against Arizona's objections and that the committee will report favorably on the requested sum of $10,660,000 to start the project. Asked how long after appropriation it would take to get the project in motion, Secretary Wilbur answered, "Five minutes."

For an apropriation to be made under the Boulder Dam Act, four elements are required: six-state ratification; approval of the compact by presidential proclamation; passage by California of an act agreeing to accept 4,400,000 acre-feet per annum as a maximum primary water apportionment; and power contracts providing revenue to amortize the project. All these points were taken up in detail in the hearings, the Interior Department's stand being that all are satisfied to the letter. Objections were directed principally at alleged flaws in the power contracts which the department has procured on the grounds that Los Angeles is without authority to contract for electrical energy from Boulder Dam and that Secretary Wilbur can not legally agree, on the basis of the Chicago diversion decision, to send water to the Metropolitan Water District outside the Colorado River basin. It is hardly expected that the committee will seek to pass upon the points of law on which these contentions are based but that the way will be paved toward court action by going through the preliminary step of approving the funds.

Western Society Holds 61st Annual Meeting

Thursday evening, May 22, marked the seasonal close of local engineering activities in Chicago, the occasion being the sixty-first annual meeting of the Western Society of Engineers, held in the Grand Ball Room of the Palmer House. Preceded by a banquet at which over 400 sat and were regaled by an excellent musical program, the meeting brought out many interesting features of the year's work. The retiring president, William S. Monroe, pointed to the activities of the society in civic affairs. For the coming year he advocated an endowment fund to be used for expansion of society work, and, to add to the general interest, a series of monthly meetings on applied science, covering recent and leading developments.

Edgar S. Nethercut, director and secretary of the society, gave an interesting account of the work of the junior engineers and among their ranks named the prize winners for the best papers presented during the season. William S. Monroe, retiring president, delivered the address of the evening, which was devoted to the development of the superpower system of the Chicago district. Many interesting facts were presented, dealing with economies, capacities, use of electricity per capita, and other data.

Officers elected for the coming year were as follows: W. O. Kurtz, president; Frank D. Chase, first vice-president; Harry B. Gear, second vice-president; Charles C. Whittier, third vice-president; Leigh S. Keith, treasurer; George W. Hand, Charles V. Weston, and H. H. Field, trustees; Rufus W. Putnam, John A. Garcia, and William S. Monroe, past presidents, and Edgar S. Nethercut, secretary.

Pulverized Coal Burner Makes Record

What is believed to be a record in the burning of pulverized coal was made recently in the power plant of the West Virginia Pulp & Paper Company's mill at Tyrone, Pa., when a Riley flare-type burner operated at sufficient capacity to liberate 140,000,000 B.t.u. per hour.

The burner is used to fire an 8,460-sq.ft. Springfield boiler equipped with water walls, which operates at a pressure of 600 lb. At the time the record was made, the boiler was generating approximately 100,000 lb. of steam an hour or about 420 per cent of its rating. The temperature of the preheated air at this rating was 550 deg. F., and the CO_2 was 15.2 per cent.

New Laboratory Building for Mellon Institute

To increase its facilities for serving American industry, the Mellon Institute of Industrial Research, Pittsburgh, Pa., will start erection of a new laboratory building early this fall, according to a recent announcement of Dr. Edward R. Weidlein, director of the Institute. Detailed plans are now being prepared for a seven-story structure of Ionic design, measuring approximately 300 ft. by 400 ft. The laboratories are to face on interior courts, so arranged that future additions can be constructed without marring the appearance of the building or interfering with the original units.

In addition to providing a greatly increased number of laboratories, the new building will give more commodious quarters for the general departments. The present library contains 11,000 volumes; the new library is planned to accommodate 250,000 volumes. Certain rooms will be equipped for specialized

phases of experimental technique, such as electrochemistry, spectroscopy, low-temperature studies, radiations, high-pressure experimentation, etc. Other special features to be included are a large lecture hall, a dining hall, an industrial fellowship museum, and an underground garage. For the past five years members of the Institute's executive staff have been visiting important laboratories in America and Europe to obtain information on new features in design and equipment.

Longstreth Medal Awarded to Ervin G. Bailey

At the Medal Day exercises held May 21 in the Hall of the Franklin Institute at Philadelphia, Pa., Ervin G. Bailey, president of the Bailey Meter Company, Cleveland, Ohio, and a widely known engineer was awarded the Edward Longstreth medal by the Institute. Mr. Bailey received the medal upon the recommendation of the Institute's Committee on Science and Arts in recognition of his many inventions and developments of regulating and controlling devices, and of measuring and recording instruments.

Mr. Bailey, who was graduated in mechanical engineering from Ohio State University Class of 1903, is an inventor of note holding many patents on instruments and equipment used in the combustion field. He is a resident of Easton, Pa., and is also president of the Fuller Lehigh Company at Fullerton, Pa., and a director of the Babcock & Wilcox Company of New York.

Southeastern States to Form Regional Council

Patterned after the New England Council, which was described in *Power* of Jan. 28, the seven states of the Southeast will set up a regional council this fall to co-ordinate the economic development of this area. The decision was reached at a recent conference of governors in Asheville, N. C., at which were present Governor O. Max Gardiner of North Carolina, Governor Henry H. Horton of Tennessee, Governor Doyle Carlton of Florida; representatives of the governors of Virginia, South Carolina, Georgia and Alabama; and leaders of business, industry and finance from each state.

Frank Page of North Carolina was appointed temporary chairman to go forward with the project and inaugurate the first Southeastern Economic Conference in October, at which it is planned to set up the Southeastern Regional Council as the working organization. This body, if it follows the New England plan, would consist of twelve councilors from each state, representative of agriculture, commerce, industry and finance, who would organize in committees to study the problems of the Southeast and its development.

Delles, Turbine Engineer, Dies Suddenly

William J. Delles, executive engineer of the turbine engineering department of the General Electric Company, died at his home in Schenectady on May 22, following a sudden attack of heart disease. Mr. Delles was to have sailed the following week as a delegate to the World Power Conference meeting in Berlin.

Graduated from Mechanics Institute of Rochester, where he was born, Mr. Delles entered the employ of the General Electric Company in the drafting department in 1898. Later he was made assistant to the manager of the Schenectady works, and in 1919 was transferred to the turbine department as assistant executive engineer. Since 1922 he was executive engineer of the department.

©Blank & Stoller

William J. Delles

International Congress for Applied Mechanics

The third International Congress for Applied Mechanics will be held in Stockholm, Sweden, Aug. 24 to 29. The first meeting of the International Congress Committee will take place at the Royal Technical University, Stockholm, Aug. 24, and the proceedings of the congress will begin Aug. 25.

A large number of papers will be presented at the technical sessions on the following general topics: Stationary engines, prime movers and motors; motors particularly used for purposes of locomotion; apparatus for producing and condensing steam; gear for the mechanical transmission of power; machine tools, hoisting, loading and unloading apparatus; and mechanical recording instruments.

In addition, a number of social events are planned, among which may be mentioned a reception at the Swedish Royal Institute of Scientific Industrial Research, and a banquet and dance to be given by the city of Stockholm. Following the congress, a sightseeing tour will be taken.

News of Canada

Beauharnois company charged with exploitation in House of Commons — New Brunswick plans new steam plant

BEAUHARNOIS Power Corporation was the subject of a heated debate in the Canadian House of Commons on May 22. Charges were made that the company's power canal project on the St. Lawrence River was a gigantic scheme to exploit the Canadian people, and that the company and its subsidiary concerns were heavily overcapitalized.

Robert Gardiner, leader of the Progressive Party, asserted that the government had, by order-in-council, approved the development over the head of the joint board of engineers which investigated the St. Lawrence deep waterway project. Further, the Beauharnois Power Corporation had violated and exceeded conditions imposed on it by the Federal order-in-council, and in so doing had committed acts which justified a demand for an explanation by the government as to whether there was an agreement between the government and the company whereby the whole of the unallocated portion of the St. Lawrence River in the vicinity of the company's development would be turned over to the company for exploitation.

It was pointed out by several members that the company had obtained approval from the Dominion government for its plan to develop 50,000 hp. in its proposed canal between Lake St. Francis and Lake St. Louis, but that the subsequent financing of the company was predicated upon the development of 1,000,000 hp., and that there was an active contemplation of a violation of the order-in-council by which approval was given to the plans. Some members called for the immediate cancellation of the company's charter.

Replying for the government, John C. Elliott, minister of public works, declared emphatically that there was no agreement between the Federal government and the power interests in regard to further exploitation of water powers by the company. He pointed out that the lease to the power company was granted by the government of Quebec, and that any conditions regarding development of power or the amount of power, could be imposed by that province and not by the Federal government. The main function of the Dominion government was to determine whether or not the project would injuriously affect navigation.

PLANS are under way by the New Brunswick Power Commission for public development of electric power from the coal resources of the province. The commission has been authorized by the Provincial government to proceed immediately with the establishment of an

electrical power plant in the Grand Lake area. There power in large quantities suitable for industrial purposes will be developed by burning the bituminous coal in which the district abounds.

The plant, which will be established at the mine heads, will burn pulverized coal. The area has reserves estimated at about seventy million tons. While definite plans have not been announced, it is stated that the plant will have a capacity sufficient to take care of all the power and household requirements of York, Sunbury, and Queen's counties. It is believed that the prospective development will provide the central section of the province with power for the farms, and for industrial and other purposes.

Brooklyn Poly to Celebrate 75th Anniversary

Polytechnic Institute of Brooklyn, N. Y., will celebrate the completion of its 75th year on June 17 and 18. An anniversary dinner under the auspices of the corporation, faculty, and alumni will be held at the St. George Hotel in Brooklyn, on the evening of the 17th. Among the speakers will be Walter Hampden, Dr. Frank Graves, New York Commissioner of Education, and Prof. Karl Compton of Princeton University, president-elect of the Massachusetts Institute of Technology.

The 75th annual commencement will be held on June 18 with Dr. Graves as commencement speaker. First honorary degrees in the history of the Institute will be conferred on Admiral Richard E. Byrd and Professor Compton.

Polytechnic Institute of Brooklyn is one of the oldest American colleges of engineering and is a pioneer in the establishment of college grade evening courses leading to the degree. Recently the Polytechnic has extended courses into the field of graduate work.

Bureau of Mines to Study Coal Carbonization

Facilities of the Pittsburgh laboratory of the United States Bureau of Mines during the coming year will be devoted largely to carbonization tests of various coals. At the Atlanta meeting of the American Chemical Society, A. C. Fieldner, of the bureau's staff, presented a paper covering the complete study made by the bureau of two types of coal. Since that time the results obtained in the laboratory have been checked in actual practice and have been found to apply to large-scale operations. This has led to requests from several coke companies and gas producers for the extension of the studies to other coals. In these studies the results are charted from the lowest to the highest temperatures.

Coming Conventions

American Society of Mechanical Engineers. Semi-Annual meeting at the Hotel Book-Cadillac, Detroit, Mich., June 9-12, 1930. Secretary, Calvin Rice, 33 West 39th St., New York City.

American Institute of Electrical Engineers. Annual summer convention at Toronto, Canada, June 23-27. Secretary, F. L. Hutchinson, 33 West 39th St., New York City.

American Order of Steam Engineers. Annual convention and mechanical exhibit at the Grand Fraternity Building, 1626 Arch St., Philadelphia, Pa., June 9-12. Secretary, William S. Wetzler, 6033 Jefferson St., Philadelphia, Pa.

American Society of Heating & Ventilating Engineers. Annual summer meeting at the Curtis Hotel, Minneapolis, Minn., June 23-25. Secretary, A. V. Hutchinson, 33 West 39th St., New York City.

American Society for Testing Materials. Annual meeting at Haddon Hall, Atlantic City, N. J., June 23-27. Secretary, C. L. Warwick, 1315 Spruce St., Philadelphia, Pa.

Association of Iron and Steel Electrical Engineers. Annual convention and iron and steel exposition at Broadway Auditorium, Buffalo, N. Y., June 16-20. Managing director, John F. Kelly, Empire Building, Pittsburgh, Pa.

Canadian Electrical Association. Annual Convention at the Manoir Richelieu via the S.S. "St. Lawrence," June 11-13, 1930. Secretary, H. M. Lyster, 405 Power Building, Montreal, Quebec.

National Association of Power Engineers. Annual convention and exhibition of power machinery at the Cleveland Auditorium, Cleveland, Ohio, Sept. 8-13. Secretary, Fred W. Raven, 417 South Dearborn St., Chicago, Ill.

National Association of Practical Refrigerating Engineers. Annual convention and exhibition at the Hotel Peabody, Memphis, Tenn., Nov. 11-14. Secretary, Edward H. Fox, 5707 West Lake St., Chicago, Ill.

National Board of Boiler and Pressure Vessel Inspectors. Annual meeting at Chattanooga, Tenn., June 17-19. Secretary, C. O. Myers, 14 Commercial National Bank Bldg., Columbus, Ohio.

National District Heating Association. Annual convention at the Coronado Hotel, St. Louis, Mo., June 3-6. Secretary, D. L. Gaskill, Greenville, Ohio.

National Electric Light Association. Annual convention at Municipal Auditorium, San Francisco, Calif., June 16-20, 1930. Secretary, A. J. Marshall, 420 Lexington Ave., New York City.

National Oil and Gas Power Meeting, under auspices of A.S.M.E. Oil and Gas Power Division and Pennsylvania State College, will be held at State College, Pa., June 12-14. Chairman, L. H. Morrison, c/o *Power*, 10th Ave. and 36th St., New York City.

Second Plenary World Power Conference. Convenes at Berlin, German, June 16-25. Chairman of the American Committee, O. C. Merrill, Edmunds Building, Washington, D. C.

Universal Craftsmen Council of Engineers. Annual convention at the Hotel Kimball, Springfield, Mass., Aug. 5-8. Secretary, T. H. Jones, 33 Linden Ave., Cherrydale, Va.

Personals

W. R. Bell, since 1926 general superintendent of the El Paso Electric Company, El Paso, Texas, has been made general superintendent of the Baton Rouge Electric Company and the Louisiana Steam Products Company, Baton Rouge, La. Succeeding Mr. Bell in El Paso will be H. C. Leonard, who has been in charge of the electrical department of the Virginia Electric & Power Company of Richmond, Va.

J. D. Stout, who has been associated with the Terry Steam Turbine Company since 1909, was recently elected vice-president of that company.

J. F. Paige, of the pulverized-fuel division of the Todd Shipyard Corporation, has resigned his position to join Christopher Strachan in forming the John Strachan Company to carry on the marine consulting business started by the late John Strachan.

Grant K. Palsgrove, professor of hydraulic engineering at Rensselaer Polytechnic Institute, Troy, N. Y., was recently elected president of the Society of Engineers of Eastern New York.

Ernest J. Opie has severed his connection with the Ramsay Chain Company of Albany, N. Y., to become chief engineer and plant manager of the Bailey-Burrus Manufacturing Company, Atlanta, Ga.

Edward N. Trump has resigned from the Solvay Process Company, with which he has been connected for the past 48 years in engineering, managerial, and executive capacities. Upon his return from the World Power Conference in Berlin, he will resume his profession as consulting mechanical and chemical engineer, with offices in Syracuse, N. Y.

A. W. Dalrymple, formerly lubricating engineer with the Texas Company in Philadelphia, Pa., is now in South America as plant superintendent of the Barranquilla station of the Cia Colombiana de Electricidad, Barranquilla, Colombia.

James A. McCrory is now in charge of design for the Power Engineering Company of Montreal, Canada.

T. W. Norcross, chief engineer of the United States Forest Service, will leave shortly for Europe to study water-power projects in a number of countries where problems are presented similar to those encountered in the development of water resources in our national forests. Mr. Norcross will also attend the meetings of the International Electrotechnical Commission at Stockholm, Sweden.

H. P. Rust, formerly with Harper and Taylor, engineers, of Philadelphia, Pa., is now with Cramp-Morris Industrials, Inc., of the same city.

Business Notes

LINCOLN ELECTRIC COMPANY, Cleveland, Ohio, announces the removal of its Baltimore distributor's office from 432 North Calvert Street to 600 North Calvert Street. T. A. Canty is in charge of distribution; R. Rude has been appointed office manager and C. N. Hilbinger sales engineer and service manager.

PALMER-BEE COMPANY, Detroit, Mich., has just opened a district sales office in New York City, at 30 Church Street, Suite 308. H. W. Ruth will be in charge of the new office.

EDGEMOOR IRON COMPANY, Wilmington, Del., reports the transfer of Thane R. Halstead from the company's home office to the Chicago office, at 1549 Otis Building, where he will be engaged in sales and engineering.

THE HAHN DIVISION of the TREADWELL ENGINEERING COMPANY, announces the appointment of J. J. Conway as district manager of New York territory. The New York office is located at 90 West St., New York, N. Y.

LINEAR PACKING & RUBBER COMPANY, Philadelphia, Pa., has moved its factory and general offices into new quarters at State Road and Levick Sts., where a new plant has been completed.

EDWARD VALVE & MANUFACTURING COMPANY, East Chicago, Ind., has appointed the Taubman Supply Corporation its representative on the Oklahoma and Northern Arkansas districts for the sale of its products. Headquarters of the Taubman corporation is at Tulsa, Okla.

CHARLES A. CARPENTER, Pittsburgh, Pa., has opened an office in the Park Building there to represent the American District Steam Company; the heating division of the Wickes Boiler Company; McKnight waste water heat reclaimers; Cork Foundation Company; and Buffalo Foundry & Machine Company.

FEDERAL PHOSPHORUS COMPANY, a division of the Swann Corporation, Birmingham, Ala., reports the transfer of G. B. Cunningham, assistant sales manager, from Birmingham to the company's New York office in the Graybar Building.

MODINE MANUFACTURING COMPANY, Racine, Wis., announces the following appointments: R. M. Gunzel & Company, representative in Los Angeles; R. F. Van Alstyne, representative in Indianapolis; J. I. Krueger, representative in San Francisco; E. W. Klein, representative in Atlanta; and R. E. Burden representative in Rockford, Ill.

JOHNS-MANVILLE CORPORATION, New York, N. Y., announces the purchase of the Stevens Sound Proofing Company, Chicago, manufacturers of patented structural products for sound insulating in walls, floors, and ceilings, and for constructing anti-vibration platforms under machinery.

UNION CARBIDE COMPANY, New York, N. Y., announces completion of the new Carbide and Carbon Building at 910 Baltimore Ave., Kansas City, Mo. Units of the corporation now housed in this building include: Linde Air Products Company; Prest-O-Lite Company, Inc.; Oxweld Acetylene Company; and Union Carbide Sales Company, as well as J. B. Colt Company, and National Carbon Company, Inc.

▼

Fuel Prices

COAL

The following table shows the trend of the spot steam market in various coals, f.o.b. mines; mine run, except Pittsburgh gas slack:

Bituminous (Net Tons)	At Mine, for Shipment to	Price per Ton
Navy Standard	New York	$2.10 @ $2.30
Kanawha	Columbus	1.35 @ 1.60
Smokeless	Cincinnati	1.90 @ 2.00
Smokeless	Chicago	2.00 @ 2.25
S. E. Kentucky	Chicago	1.35 @ 1.60
Steam	Pittsburgh	1.50 @ 1.60
Gas Slack	Pittsburgh	.90 @ 1.10
Big Seam	Birmingham	1.50 @ 1.75

Anthracite (Gross Tons)	At Mine, for Shipment to	Price per Ton
Buckwheat	New York	$3.00
Barley	New York	1.25 @ 1.50

FUEL OIL

New York—May 29, f.o.b. Bayonne, N. J., 28@34 deg., Baumé, industrial use, tank-car lots, 4.75@5.25c. per gal.; f.o.b. Bayway, 36@40 deg., furnace, tank-car lots, 6c.@6.25c. per gal.

St. Louis—May 22, tank-car lots, f.o.b. St. Louis, 24@26 deg., $1.47 per bbl., or 42 gal.; 26@28 deg., $1.54 per bbl.; 28@30 deg., $1.65 per bbl.; 30@32 deg. $1.70 per bbl.; 32@36 deg., gas oil, 4.15c. per gal.; 37@40 deg., distillate, 4.98c. per gal.

Pittsburgh—May 21, f.o.b. local refinery, 30@34 deg., fuel oil, 4c. per gal.; 36@40 deg., 4@4.25c.

Philadelphia — May 21, 13@19 deg., $1.05@$1.10 per bbl. or 42 gal.; 18 deg. plus, $1.475@$1.525 per bbl.; 23@27 deg., $2.00@$2.05 per bbl.

Cincinnati — May 27, tank-car lots, f.o.b. local refinery, 24@26 deg. Baumé, 5.25c. per gal.; 26@30 deg., 5.5c. per gal.; 30@32 deg., 5.75c. per gal.

Chicago—May 21, tank-car lots, f.o.b. Oklahoma, freight to Chicago, 90c. per bbl. or 42 gal.; 22@26 deg., 75@80c. per bbl.; 26@30 deg., 85@90c. per bbl.; 30@32 deg., $1.00@$1.05 per bbl.

Boston—May 26, tank-car lots, f.o.b., 12@14 deg., Baumé, 3.3c. per gal.; 28@32 deg., 5c. per gal.

Dallas—May 24, f.o.b. local refinery 26@30 deg., $1.25 per bbl. or 42 gallons.

Trade Catalogs

BLOWERS—The latest edition of Bulletin 4-T, a section of the general catalog of the Schutte & Koerting Company, Philadelphia, Pa., describes compressed-air blow guns and forge blowers.

GENERATORS — Motor-generator sets for converting alternating current to direct current are listed in Bulletin No. 500 put out by the Reliance Electric & Engineering Company, Ivanhoe Road, Cleveland, Ohio.

STEAM TURBINES—The general principles and construction of General Electric steam turbine-generators are given in a new booklet, GEA-1011A, published by the General Electric Company, Schenectady, N. Y.

BOILERS—A series of six articles by Joseph Harrington on the "Efficient Firing of Small Boilers" is being circulated by the Whiting Corporation, Harvey, Ill. A continuous ash discharge and and even fuel bed are discussed in the first two of this group, which are now ready for distribution.

INSTRUMENTS — The Paragon Megohmer, an instrument for measuring the insulation resistance of cables, transformers, generators, suspension-type insulators, and similar high-tension equipment, is described in Bulletin No. 195 of the Herman H. Sticht Company, 15 Park Row, New York, N. Y.

REGULATORS—The Swartwout Company, 18511 Euclid Ave., Cleveland, Ohio, has just printed a new Bulletin, No. S-22-A, on "Pressure Regulation," which illustrates some of the applications handled by the "S-C" master control and auxiliary equipment.

FIREBRICK—Under the title "A Complete Tunnel Kiln Plant," the new booklet published by the A. P. Green Fire Brick Company, Mexico, Mo., describes the three plants of this unit. Clay deposits, laboratories, manufacturing, executive and general offices are all grouped at the plant.

BURNERS — The DFC atmospheric-type gas burner of the Denver Fire Clay Company, 1742 Champa St., Denver, Colo., is described and illustrated in Bulletin No. 305, recently distributed.

STEAM CONDENSERS—A fully illustrated description of Wheeler steam condensers is contained in a current catalog published by the C. H. Wheeler Manufacturing Company, Philadelphia, Pa. Subjects covered in this 130-page booklet are, elements and economics of the condensing process, jet and surface condensers and condensing equipment.

METERS—Various types of demand meters are illustrated and described in Catalog GEA-612 put out by the General Electric Company, Schenectady, N. Y.

New Plant Construction

COMPILED BY THE McGRAW-HILL BUSINESS NEWS DEPARTMENT, WHICH IS PREPARED TO FURNISH A MORE COMPLETE DAILY SERVICE TO THOSE WHO WISH IT

Calif., Los Angeles—Sun Realty & Finance Co., 727 West 7th St., awarded contract for the construction of a 12 story office and loft building at 629-633 South Hill St., to H. M. Baruch Corp., 742 South Hill St. Estimated cost $750,000. Steam heating system, elevators, etc., will be installed.

Conn., New Haven—United Illuminating Co., 128 Temple St., awarded contract for extensions to power plant, including 12,500 kw. generator, etc., to Dwight Building Co., 67 Church St. Estimated cost to exceed $150,000.

Ill., Chicago—Commonwealth Edison Co., 72 West Adams St., awarded contract for a 2 story, 254 x 330 ft. service station at California Ave. and Addison St. to Great Lakes Construction Co., 333 North Michigan Ave. Estimated cost $1,000,000.

Kan., Wichita—Bd. of Education, L. Gerteis, Secy., 406 York Rite Temple Bldg., awarded contract for the construction of a 2 story, 59 x 105 ft. school, including boiler room to H. W. Underhill, 235 North Waco St., $42,462.

Md., Baltimore — Buena Vista Apartment Corp., Garrett Bldg., is having plans prepared for a 10 story apartment building, including vacuum steam heating system, elevators, etc., at Charles and 33rd Sts. Estimated cost $650,000. F. R. White, Garrett Bldg., is architect.

Mass., Braintree (br. Boston)—Norfolk Hospital, Norfolk County Commission, Dedham, awarded contract for the construction of a boiler house to John Macdonald Construction Co., 100 Arlington St., Boston. Estimated cost to exceed $40,000. Contracts for boilers chimney and refrigeration awarded.

Mass., Concord—Edison Electric Illuminating Co., 39 Boylston St., Boston, awarded contract for the construction of a power substation at Main St. and Nine Acre Rd. to G. H. B. Macomber Co., 38 Chauncy St., Boston. Estimated cost $50,000.

Mass., Newton (br. Boston)—Dept. of Public Buildings, will not construct boiler house addition at Technical High School, Newtonville. $50,000. Project in abeyance.

Mass., Taunton — City will build a power sub-station on Meadow St. Estimated cost $40,000. Private plans. Work will be done by separate contracts.

Minn., Duluth—Minnesota Power & Light Co., W. H. Burke, Pres., 30 West Superior St., plans the construction of a steam generating plant, on the St. Louis River, initial capacity 25,000 hp., ultimate total capacity 250,000 hp. Estimated cost $3,500,000. Contract for causeway awarded to C. R. McLean, 515 South 21st Ave., and pile driving to Whiney Bros., 909 Alworth Bldg.

Minn., St. Paul—John W. Norton Co., 600 Shubert Bldg., plans the construction of a 6 story office and warehouse, including steam heating system, etc., at University and Raymond Aves. Estimated cost $750,000. Buechner & Orth, 500 Shubert Bldg., St. Paul, are architects.

Minn., St. Paul—Northern States Power Co., 15 South 5th St., Minneapolis, awarded contract for a 6 story office building to Foley Bros. Inc., 208 Gilfillan Pl., St. Paul. Estimated cost $600,000. Steam heating system, etc., will be installed.

Mont., Great Falls—J. M. Murphy, has been granted franchise to construct a central heating plant and distribution system. Estimated cost $100,000.

Neb., Nehawka—City, J. H. Steffens, Clk., plans an election June 10 to vote $21,000 bonds for waterworks improvements, including turbine pump house, etc. Henningson Engineering Co., Omaha, is engineer.

N. J., Allenhurst—Morris & Erskine, 1716 Cherry St., Philadelphia, Pa., Archts., are receiving bids for the construction of a 4 story hospital, nurses' home, etc., including steam heating and ventilation systems, boilers, elevators, etc., here, for Ann May Hospital, A. E. Fitkin, Secy., First Ave., Spring Lake. Estimated cost $1,000,000.

N. J., Freehold — Bd. of Council, Municipal Bldg., is having plans prepared for the construction of a sewage disposal plant including pumping station, etc. Estimated cost $106,400. W. J. Schiverea, is engineer.

N. J., Hackettstown — Centenary Collegiate Institute, Church St., is having plans prepared for a 1 story, 30 x 60 ft. boiler house. Estimated cost $40,000. F. W. Wentworth, 140 Market St., Paterson, is architect.

N. J., Princeton — Princeton Water Co., awarded contract for the construction of waterworks pumping station, aerator and three storage bins in connection with waterworks to Merritt, Chapman & Scott, 17 Battery Pl., New York, N. Y. $25,000. Pumping equipment let to Turbine Equipment Co., 30 Church St., New York.

N. Y., New York—Bd. of Transportation, J. H. Delaney, Chn., awarded contract for the construction of sub-stations 5 and 6, to R. E. Smith Co., 303 West 42nd St.

O., Cleveland—Cleveland Terminal Buildings Co., C. L. Bradley, Pres., Terminal Tower, awarded contract for caissons, piling and spread footings for a 12 story department store including steam heating system, etc. at Public Sq., Ontario St. and Prospect Ave. Estimated cost $9,000,000. Graham, Anderson, Probst & White, Railway Exchange Bldg., Chicago, Ill., are architects and engineers. Higbee Co., East 14th St. and Euclid Ave., is lessee.

O., New Boston—Ohio Power Co., 301 Cleveland Ave., plans the construction of a 2 story sub-station here. Estimated cost $40,000. Private plans.

Pa., Philadelphia — Constructing Quartermaster, will soon award contract for demolition of old boiler house and erection of new boiler house, also repairs to chimney at Schuylkill Arsenal.

Tex., Shamrock—Panhandle Power & Light Co., Amarillo, and Shamrock, plans the construction of a power plant near here. Estimated cost $3,000,000.

Va., Holybrook — St. Joseph's Orphanage, will receive bids about June 1, for the construction of a group of buildings, including heating plant, etc. Estimated cost $1,000,000.

Wash., Centralia — Puget Sound Bridge & Dredging Co., Central Bldg., Seattle, awarded contract for electrical work in connection with city's municipal power project. Contract calls for construction of 25½ mi. of 60,000 v. transmission line; placing 71 mi. of No. 10 telephone copper wire, wiring of power house and substation, erecting bus structure and connecting all equipment, including transformers, generators, and switches to City Light & Fixture Co., 216 James St., Seattle. Estimated cost $90,000. B. A. Travis, c/o Contr. Electrical engineer in charge of work.

Wash., Seattle—City will receive bids about June 20, for the construction of two pumping plants in connection with sewage treatment work. Estimated cost $140,000. W. D. Barkhuff, is engineer.

W. Va., Morgantown—State Bd. of Control, Charleston, will receive bids until June 10 for a steam tunnel and equipment to connect up new library building at West Virginia University here.

Ont., Ottawa — Bd. of Governors, Water Street General Hospital, Water St., plans a 3 or 4 story addition, also remodeling present hospital building including steam heating system, etc. Estimated cost $1,000,000. Architect not selected.

Equipment Wanted

Boiler—Los Angeles, Calif.—County Supervisors, will soon receive bids for the installation of a 150 hp. boiler at Olive View Sanitarium.

Boiler and Stoker — Wallum Lake, R. I. — Purchasing Agent, Howard, will receive bids until June 5, for a 250 hp. 3 drum Sterling type water tube boiler and accessories and three hand stoker at State Sanatorium, here.

Boilers—Pasadena, Calif.—City will soon receive bids for two boilers for municipal light plant. Estimated cost $210,000.

Engine—Boston, Mass.—Central Equipment Co., 31 State St., is in the market for a 7 x 10 double drum hoisting engine with Massachusetts Standard boiler, 125 lb. pressure.

Engines and Generators—Chelsea, Okla.—City plans the installation of two 300 hp. Diesel engines and generators in municipal electric light plant. Estimated cost $40,000.

Pumps—Kilbuck, O.—City will soon receive bids for pumps, etc. for proposed waterworks improvements. Estimated cost $35,000.

Transformers—Columbus, O.—Bd. of Purchases, H. C. Cain, Secy., will receive bids until June 5 for twenty 15 kva., four 25 kva., six 37½ kva. and six 75 kva., 6900-230/115 v. distribution transformers, also three 37½ kva. and two 50 kva., 6900-460/230 v. distribution transformers for electric light plant.

Turbine, Generator, Transformers, etc. — Wyoming — Bureau of Reclamation, Denver, Colo., will receive bids until July 1, for 6,000 hp. vertical hydraulic turbine with governor and governor pump; governor operated pressure regulator, 66 in. motor-operated butterfly valve, 5,000 kva. a.c. generator; four 1,667 kva. 2,300 to 19,000/33,000 v. transformers; switchboard and auxiliary apparatus for Shoshone power plant, Shoshone project, here.

Industrial Projects

Calif., Baggett — Western Borax Co., 417 South Hill St., Los Angeles, awarded contract for the construction of a 73 x 110 and 73 x 120 ft. factory and six 1,000 bbl. capacity steel tanks here to Consolidated Steel Corp., 1200 North Main St., Los Angeles.

Calif., Wilmington—Union Oil Co., L. G. Metcalf, Mgr., awarded contract for the construction of a 1 story, 130 x 180 ft. oil refinery to J. Simpson & Co., 701 Antonio St., Los Angeles. Estimated cost $600,000.

Conn., Stamford—Norma Hoffman Bearings Co., Hamilton St., awarded contract for the construction of a 1 and 2 story, 100 x 200 ft. factory to Hewlett Co., 886 Main St., Bridgeport. Estimated cost $125,000.

Conn., Waterbury — American Brass Co., Grand and Meadow Sts., awarded contract for a 1 story, 140 x 160 and 140 x 205 ft. brass tube mill on South Main St., to Oscar LaCroix Construction Co., 51 West Main St. Estimated cost $300,000.

Conn., Waterbury—Lux Clock Co., 97 Perry St., awarded contract for a 4 story, 35 x 80 ft. factory to Oscar LaCroix Construction Co., 51 West Main St. Estimated cost $75,000.

Ill., Chicago — Western Electric Co., 195 Broadway, New York, N. Y., will receive bids about July 1, for the construction of a factory, here. Estimated cost $1,000,000. Condron & Post, 53 West Jackson Blvd., Chicago, Ill., and 11 Park Row, New York, are architects and engineers.

Ill., Granite City—Union Starch & Refining Co., Columbus, awarded contract for a 4 story, 70 x 130 ft. factory here to S. M. Wilson, Granite City. Estimated cost $100,000. Equipment will be required.

Ia., Waterloo — John Deere Tractor Co., awarded contract for the construction of a 1 story, 160 x 240 ft. wheel manufacturing plant on Miles St., to Jens Oleson & Sons Construction Co., 1522 Lafayette St. Estimated cost $125,000.

Me., Rumford—Oxford Paper Co., Main St., awarded contract for the construction of a 1 story, 95 x 120 ft. boiler plant on Main St. to M. C. Tuttle Co., 31 St. James Ave., Boston, Mass. Estimated cost $50,000.

Md., Baltimore—Hinde & Dauch Paper Co., Sandusky, O., had plans prepared for a 1 story, 240 x 480 ft. paper plant at Biddle St. and Loney's Lane. Estimated cost $400,000. Otto Randolph Inc., 53 West Jackson Blvd., Chicago, Ill., is architect.

Mo., St. Louis—Warson Petroleum Co., Inc., Paul Brown Bldg., awarded contract for a 1 and 2 story oil storage and distribution plant, including 300 hp. boiler plant at Mackling Ave. and Missouri Pacific R.R. to The Austin Co., Arcade Bldg. Estimated cost $250,000.

N. J., Jersey City—Adam Black & Sons Inc., 54 Cambridge Ave., awarded contract for a 1 story, 150 x 260 ft. automobile body manufacturing plant on Tonnele Ave. to A. W. Crone & Son Inc., 338 Palisade Ave. Estimated cost $100,000.

N. J., Jersey City—B. Singer, 921 Bergen Ave., Archt., will receive bids about June 1, for a 2 story, 45 x 140 ft. factory at Crawford St. for Jersey City Ladder Co. Inc., 677 Montgomery St. Estimated cost $40,000.

N. Y., Flushing—I. B. Kleinert Rubber Co., 18th St. and 5th Ave., awarded contract for a 28 x 50 ft. addition to boiler plant to W. Kidde & Co., 140 Cedar St., New York. Estimated cost $40,000.

Pa., Philadelphia—C. Kahn, Provident Trust Bldg., plans the construction of a 1 story, 42 x 76 and 52 x 67 ft. factory at Stokely and Westmoreland Ave. Estimated cost $50,000. E. A. Stopper, 10 South 18th St., is architect. Ryan Scully Co., Wissahicken and Kelland Sts., manufacturers of furnaces, is lessee.

Ont., Chippewa — Norton Co. Ltd., awarded contract for a 2 story addition to abrasive manufacturing plant to Smith Bros. Construction Co., Niagara Falls. Estimated cost $60,000. Private plans.

Ont., London—Jones Box & Label Co., F. F. Jones, Mgr., Dundas St. E., awarded contract for the construction of a 4 story addition to factory to Fleet Construction Co., Toronto. Estimated cost $60,000. Complete new box label machinery will be required.

Ont., Welland—Page-Hersey Tubes Ltd., 100 Church St., Toronto, awarded contract for founations for 1 story, 75 x 800 ft. tube mill, here. Estimated cost $2,000,000. Private plans.